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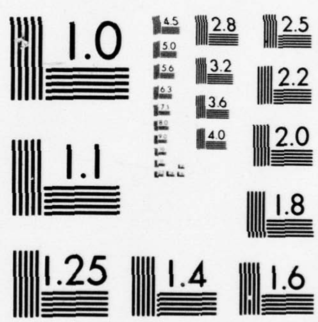

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MANUFACTURING METHODS AND TECHNOLOGY ENGINEERING (MM&TE) PROGRAM FOR THE ESTABLISHMENT OF PRODUCTION TECHNIQUES FOR HIGH DENSITY THICK FILM CIRCUITS USED IN CRYSTAL OSCILLATORS

FOURTH QUARTERLY PROGRESS REPORT
29 MAY 1977 - 27 AUGUST 1977

CONTRACT NO. DAAB07-76-C-8119

PLACED BY

PRODUCTION DIVISION
PROCUREMENT AND PRODUCTION DIRECTORATE
USAECOM, FORT MONMOUTH, N.J. 07703

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PREPARED BY

RAYTHEON COMPANY
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Production techniques are being established for a thick film hybrid microelectronic 17-22 MHz, temperature-compensated, voltage-controlled crystal oscillator. In the engineering phase of the program, the redesign of the VCXO and TCFG substrates to relieve corral dimension and circuit density problems has been completed. The first lot of engineering samples has progressed through pre-aging electrical testing, and 5 units were undergoing aging at the close of the period. These units are non-conforming, having been assembled prior to the redesign effort. Units using redesigned substrates are in process.

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FOURTH QUARTERLY PROGRESS REPORT
29 MAY 1977 - 27 AUGUST 1977

CONTRACT NO. DAAB07-76-C-8119

PRESENTED BY

C. G. ALEX

PREPARED BY

CHARLES T. MARTIN
RICHARD COLSON
CHARLES MORRIS

OBJECT OF STUDY

The objectives of the program are to establish production techniques for high density thick film hybrid microcircuits used in crystal oscillators and to produce quantities of a 20 MHz temperature - compensated, voltage - controlled crystal oscillator (TCVCXO) using these techniques.

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ABSTRACT

Production techniques are being established for a thick film hybrid microeoelectronic 17-22 MHz, temperature-compensated, voltage-controlled crystal oscillator. In the engineering phase of the program, the redesign of the VCXO and TCFG substrates to relieve corral dimension and circuit density problems has been completed. The first lot of engineering samples has progressed through the pre-aging electrical testing, and five units were undergoing aging at the close of the period. These units are non-conforming, having been assembled pri or to the redesign effort. The second lot of engineering samples, using the redesigned substrates, is in process.

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The engineering phase of this manufacturing methods and technology program consists of the following tasks:

1. Elecrical breadboard construction
2. Breadboard evaluation
3. Module configuration design
4. Process flow plan generation
5. Hybrid microcircuit parts selection
6. Hybrid microcircuit parts and bonding tools procurement
7. Thick film processing materials procurement
8. Potting shells and encapsulant materials procurement
9. Hybrid microcircuit layout design
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12. Assembly drawing generation
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21. Thick film substrate fabrication
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23. Electrical testing of substrate assemblies (pre-seal tests) (10-lot)
24. Hermetic sealing of substrate assemblies (10-lot)
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35. Electrical testing of assembled modules (pre-pot tests) (15-lot)
36. Module encapsulation (15-lot, as required)
37. Electrical testing of encapsulated modules (post-pot tests) (15-lot, as required).
38. Module aging (15-lot)
39. Electrical testing of modules (final tests) (15-lot)

The 10-lot and 15-lot designations refer to the two lots of deliverable engineering samples required by the contract. At the close of the 4th quarter, the following items were considered to be completed: 1-3, 5, 7-14, 18, 20, 22-27. Work is continuing on items 4, 6, 15-17, 19, 21, 28, 30.

Like previous reports, this report is divided into four major categories for purposes of discussion: Process Development, Fixturing and Tooling, Substrate Assembly, and Module Assembly and Testing.

2.0 PROCESS DEVELOPMENT

2.1 Parallel-Seam Soldering and Welding

Seam-soldering experiments were conducted during the third quarter using gold-tin solder preforms. Visual examination of the soldered parts showed inconsistent flow and wetting of the solder. Gross leaks were revealed at the poorly wetted areas. It was suspected that the parts had not been properly cleaned.

Because of the unsuccessful experiments with parallel-seam soldering, both TCFG and VCXO substrate assemblies were oven sealed for use in fabricating the 10-lot modules by a parallel-seam welding process. Further experiments with parallel-seam soldering were not conducted during this report period.

Leak testing of the sealed substrates revealed fine leaks in some of the welds. It is presumed that these leaks were caused by non-optimized welding currents and pressures. For example, too low a welding current would cause leaks, while too high a welding current would heat and fracture the corral glass, thus causing leaks at that interface. The sealing process investigation is continuing, and the process will be refined for use on future lots.

2.2 Test Procedures

Test procedures for use during module production have been completed. These are:

- TCFG Functional
- VCXO Functional
- TCVCXO Functional
- TCVCXO Transient Frequency Stability
- TCVCXO Temperature Stability
- TCFG Functional Trim
- VCXO Functional Trim

3.0 FIXTURING AND TOOLING

3.1 Trimming Holding Fixture

In attempting to trim VCXO substrate assemblies to a given oscillator frequency, spurious oscillations made frequency measurements difficult. Since these oscillations had not occurred during functional testing, it was assumed to be a laser fixturing problem. Therefore, the trimming holding fixture was modified to incorporate the use of an edge connector during functional trimming of VCXO substrate assemblies. This was necessary since the occurrence of spurious oscillations with the initial set-up indicated the need for contact between the crystal and the VCXO assembly more intimate than probes could provide. The fixture will be further modfied to incorporate a thermocouple to aid in TCFG functional trimming.

The modified fixture was used to finish the VCXO substrate trims with no further oscillation problems. However, difficulties were encountered in trimming for the 2000 Hz frequency shift because of the limited trim ranges of the resistors involved. This problem has been corrected by the VCXO substrate redesign.

3.2 Compatible Substrate Tooling for Laser Trimmer and Screening Equipment

To provide accurate registration between the thick-film screener and laser trimmer, similar sets of substrate mounting fixtures are being fabricated for each piece of equipment. The substrate edge will touch at one point in the short dimension and at two points in the long dimension.

3.3 Test Fixturing

The test fixture designed and fabricated for module temperature testing completed the test fixturing effort on the engineering phase of the TCVCXO program.

4.0 SUBSTRATE ASSEMBLY (10-lot samples)

4.1 Substrate Redesign

Problems were encountered during the third quarter in the assembly and passive trim of the TCFG and VCXO substrates for the 10-lot construction effort. The major difficulty resulted from the fact that the glass fillets of the corrals extended toward the substrate interior more than had been anticipated. In some places, the fillets partially covered resistors and made trimming difficult. In the assembly operation, the corral dimensions and the circuit density prevented the use of conventional die-bonding and beam-lead-bonding tools.

Several alternative solutions were considered. One possible solution to the trimming problem, passive trimming before corral attachment, was rejected because the greater than 500°C heat required in the corral attach process could seriously affect resistor values.

Changes in the corral shape were investigated but were abandoned because of structural weakness, assembly complexity (involving added cost and/or extended time of operation), or potential hermetic sealing problems.

Eventually, it was determined that the best solution would be a redesign of both substrates. However, implementation of this redesign required several changes in the design ground rules.

a. Both TCFG and VCXO substrate assemblies were changed from three to four resistor paste blends to achieve better control of resistor as-fired values.

b. The use of beam-lead devices was abandoned in favor of chip-and-wire devices because of the non-availability of the former and to increase reliability.

The TCFG substrate assembly redesign was accomplished without a great deal of difficulty. The layout was shown in Figure 5-1 of the third quarterly report.

For the VCXO hybrid assembly, a more drastic change in concept was required to make the circuit manufacturable. Because there was no room on the substrates to move various devices away from the corral wall, it was decided eventually to move part of the circuitry into the large vacant space which had been reserved for the flatpack crystal mounting pad, since the HC-18 crystal then being used pending the availability of the ceramic flatpack, was mounted outside the substrate. A logical candidate for use of the area was the 9-volt regulator circuit, which has been so designed that it can be removed at a later date and placed into a separate external package when the flatpack crystals become available. The redesigned VCXO layout is shown in Figure 4-1. It can be compared with the original layout shown in Figure 2-4 of the second quarterly report.

All necessary art work for both TCFG and VCXO substrate layout redesigns has been generated and new printing screens reflecting the 10-lot sample submission were completed.

4.2 Trimming Efforts

The VCXO substrate was passively trimmed on the abrasive trimmer. Initial efforts indicated that this is an appropriate technique. However, some difficulties arose in determining resistor loops and subsequent probe placement.

The TCFG active trim procedure has been reviewed. The main areas of concern are the placement of the probe for monitoring substrate temperature and selection of an appropriate AC ratio meter for gain adjustments. It is thought that temperature probe placement can be accomplished by taping to the substrate near the edge connector pins.

Trim probe cards for both TCFG and VCXO are being defined and ordered.

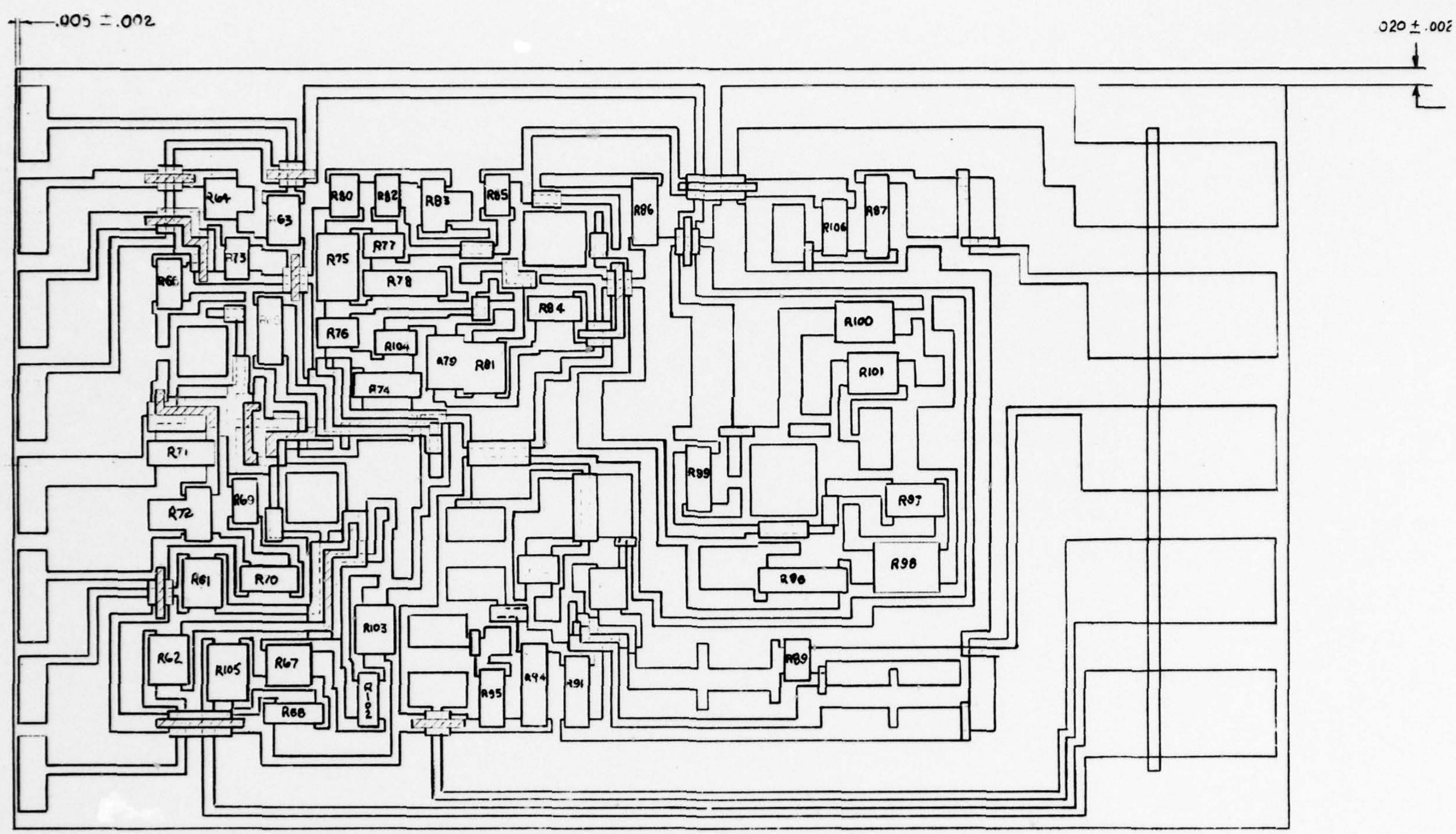


Figure 4-1. Substrate Component Assembly VCXO Hybrid Regulator Version

5.0 MODULE ASSEMBLY AND TESTING (10-lot samples)

The first engineering samples of the TCVCXO modules were assembled for the 10-lot submission. Although no problems were encountered, soldering the ribbon jumpers in place took longer than anticipated. However, because of yield loss in resistor trimming and VCXO substrate assembly, there was only enough material to assemble 8 TCVCXO modules. The 2-unit deficit in the 10-lot delivery will not be made up since both substrate assemblies have been redesigned. The present 10-lot modules are nonrepresentative of future builds.

5.1 Pre-Aging Electrical Testing (10-lot samples)

The pre-aging electrical testing of the TCVCXO modules was carried out in 3 phases in compliance with the referenced Test Requirements Specification (TRS):

1. Functional Test (TRS 31388)
2. Transient Frequency Stability Test (TRS 31389)
3. Temperature Test (TRS 31390)

Copies of the specifications are included in the Appendix.

Although the problems involved in functional trimming prevented meeting specifications entirely, 7 of 8 units subjected to fuctional test were considered working, and data were recorded. The eighth sample would not oscillate after assembly and is being fault isolated.

The remaining 7 units were temperature tested over a range of-40° to +75°C. During these tests, the modules' center frequencies and upper and lower deviations were plotted. Two modules failed this test, both showing large frequency shifts with temperature. The remaining 5 units looked good except in the -30° to -40° C range, where the frequency tailed off on all 5 units.

Transient frequency stability testing showed all 5 modules to be stable within 1 Hz over the 5 to 100 ms test range.

Copies of the test data sheets for the 8 modules subjected to pre-aging electrical testing are included in the Appendix.

5.2 Description of Test Setups

5.2.1 Functional Tests

The functional tests were accomplished by means of the test setup shown in Figure 1 of TRS 31388. The circuitry within the Functional Test Box, as shown in Figure 5-1, consists of the components necessary to switch the input voltages and output loading as required to perform the tests listed in Table 5-1.

The input supply voltage is derived from Zener diodes and may be switched between +10, +12, and +15 volts for the frequency/voltage sensitivity test. The voltage may be applied through a series transistor switch, normally shorted, which is used to interrupt periodically the supply voltage for the transient stability test. The input current is measured by clipping a DC current probe on a current loop which is in series with the transistor switch.

A 5-volt zener diode provides a level for the digital and control inputs, which may be switched separately between ground and 5 volts. The analog voltage input is derived from a low impedance resistor network fed by an external +2.4-volt source. The various voltage levels are selected from taps by means of a switching arrangement which also permits a symmetric reversal of levels. An AC signal may also be switched in, either directly or through a 200K ohm resistor, for the analog input impedance measurement. The output loading may be varied between 1200, 1000, and 800 ohms by switching.

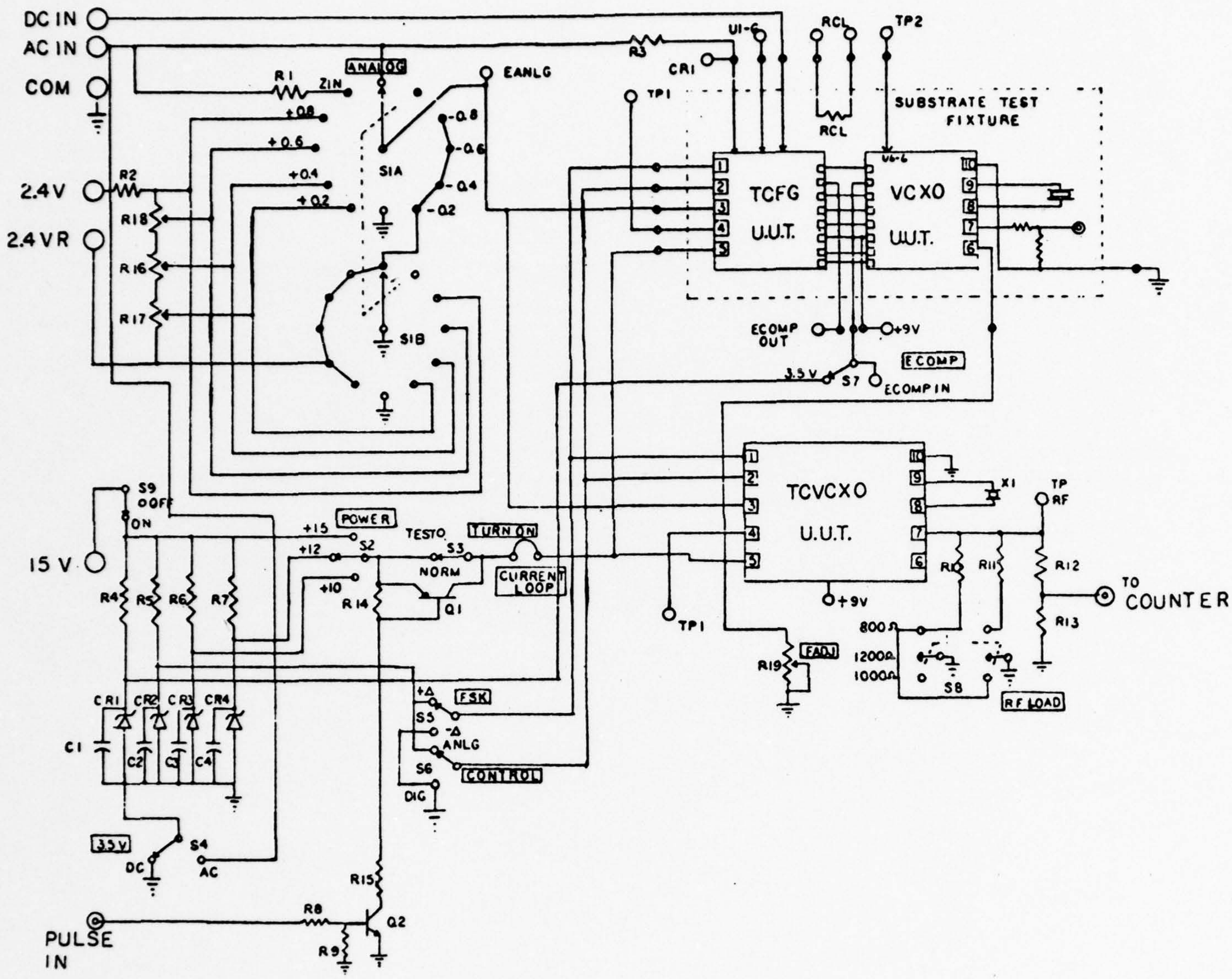


Figure 5-1. Schematic Diagram of Functional Test Box

Table 5-1 Pre-Aging Functional Tests - Data Summary

Test	Unit	Spec Limit	Module Serial No. 1	2	3	4	5	7	8
Input Power	ma	4.16 (max)	3.45	3.55	3.40	3.45	3.20	3.50	3.45
Output Voltage	Vpp	1.50 (min)	1.10	1.12	1.00	1.20	1.12	1.20	1.20
Frequency vs 12V	±ppm	0.25 (max)	0.19	0.00	0.11	0.11	0.06	0.06	0.00
Frequency vs Load	±ppm	0.25 (max)	0.19	0.11	0.11	0.11	0.11	0.11	0.11
Analog Zin	KΩ	200KΩ (min)	196	184	194	186	191	189	187
Analog Deviation Sensitivity	Hz/V	500	466	471	574	453	454	460	452
Analog Deviation Linerarity	± %	5(max)	2.4	1.6	2.5	1.9	1.4	1.2	1.4
FSK Deviation	±Hz	300(min) 325(max)							
FSK Deviation Total	Hz	600(min) 650(max)	427	573	712	547	504	558	549
Frequency Adjustment	±ppm	5(min)	52	53	53	48	54	57	54

5.2.2 Transient Stabiltiy Tests

The test setup used for the transient stablity test is shown in Figure 5-2. It is an alternate setup to that shown in Figure 1 of TRS 31389 and uses the HP 5306A computing frequency counter in a slightly different manner. In this setup, the pulse generator applies 12 volts to the unit under test through the series transistor switch in the Functional Test Box, and simultaneously triggers the delay circuit in the oscilloscope. The delayed sweep from the scope is then used to furnish a counting interval to the HP 5360A counter. The duration of the delayed sweep is 10 ms to provide a resolution of 1 Hz, and the position of the sweep is controlled by the scope delay setting. Thus, the counting interval is visible as a brightened segment of the oscillator output trace. The counting interval is positioned from 5 to 15 ms and 90 to 100 ms in accordance with specification requirements, but it can also be varied continuously along the outer trace to verify that the frequency is stable throughout.

5.2.3 Temperature Testing

The test setup shown in Figure 1 of TRS 31390, with one change, was used to generate the temperature characteristics as required by the product specification. Because a D/A converter was not available, the RF output was beat against a stable source in a mixer, and the difference frequency was fed to an F/V converter. The output of the F/V converter was then used to drive the Y channel of the XY plotter.

The electronic switch, designed for this setup, is used to switch the analog input between zero volts and symmetric positive and negative levels, while coordinating the lifting and dropping of the pen to prevent smearing. A more complete description of this unit was given in the Third Quarterly Progress Report.

The oven temperature is varied at a constant rate by means of a motor-driven potentiometer. The temperature is sensed with an RCL

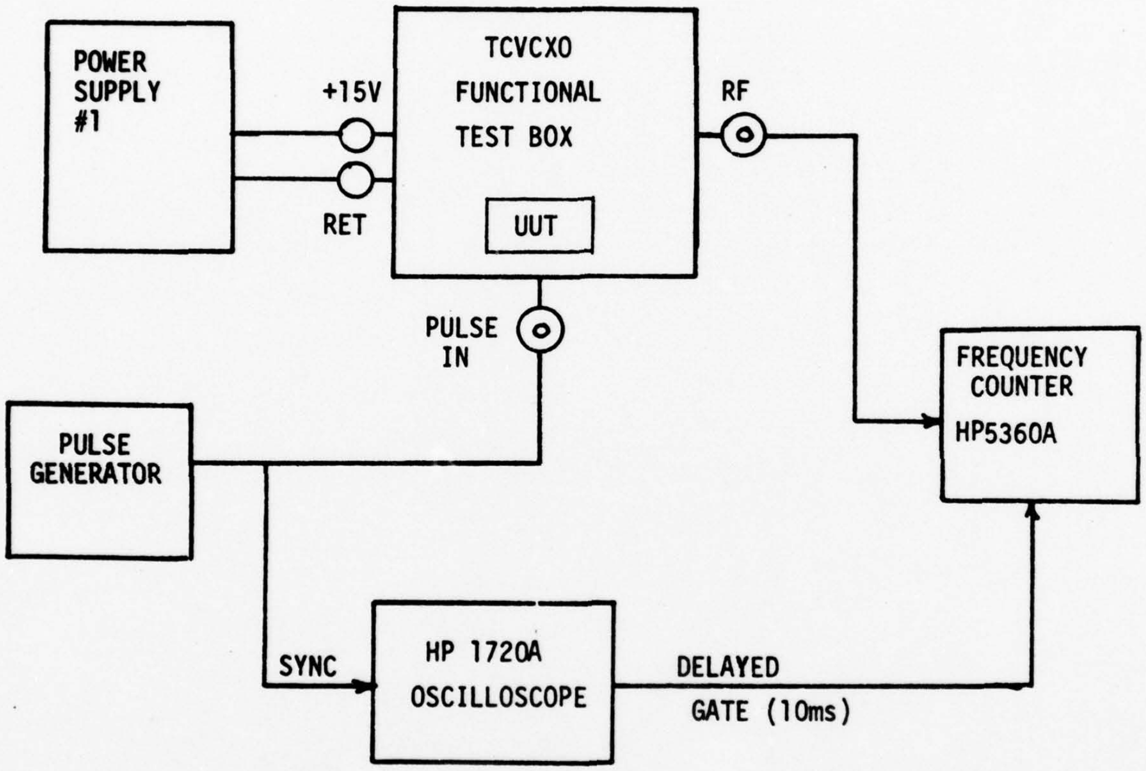


Figure 5-2. Transient Stability Test Setup
Alternate Method

temperature-sensitive wire-wound resistor with a constant positive temperature coefficient. The RCL sensor is used in a bridge to provide a DC voltage output which is proportional to temperature, this voltage then being used to drive the X channel of the plotter.

The setup is limited to testing one unit at a time.

5.3 Discussion of Tests

5.3.1 Functional Tests

The data recorded for the pre-aging functional tests are summarized in Table 5-1, with specification limits included for reference.

a. Input Power (SCS-483, para. 3.2.3). The measurement was made with the supply voltage at the nominal value of +12.0 volts. This corresponds to an average power of about 42 mw, which is comfortably below specification maximum of 50 mw. At the maximum value of 15 volts, however, the average power would be just out of specification at about 52 mw. It is recommended that the specification be clarified with respect to the supply voltage.

b. Output Voltage (SCS-483, para. 3.2.4). The RF voltages ranged from 1.1 to 1.2 volts peak-to-peak, which is below the required minimum of 1.5 Vpp listed on the data sheets. The limit is actually specified as 0.5 volts rms in SCS-483, which is equivalent to 1.41 Vpp for a sinusoid. Measurement accuracy could be improved by using an RV voltmeter rather than an oscilloscope, although unusual waveforms, if any, would not be so detected. Possibly a specification for output distortion should be considered in view of the nonlinear waveform. Such a measurement might also be desirable

for high volume testing where individual waveforms would not normally be visually observed.

c. Frequency-Voltage Stability (SCS-483, para. 3.11). The frequency-voltage stability is specified as $\pm$ 0.25 ppm, for a supply voltage variation of +3 volt and -2 volt about a nominal of +12 volt. Performance data indicate that this requirement is readily met.

d. Frequency-Load Stability (SCS-483, para. 3.12). As with the frequency-voltage stability, the limit is $\pm$ 0.25 ppm for a load variation of 1000 ohm $\pm$ 200 ohm. The data sheets show a typical frequency change of $\pm$ 0.11 ppm which is well within specification limits.

e. Analog Input Impedance (SCS-483, para. 3-19). The analog input impedance is determined essentially by comparing the unknown Zin with a resistor in the functional test box which is known to be 200K within 0.1%. The value of Zin is computed from the formula:

$$\text{Zin} = \frac{200\text{K}\ \Omega}{\frac{\text{Vcal}}{\text{Vz}} - 1}$$

Where Vcal and Vz are the voltages measured at terminals AC_{in} and E_{anlg} of Fiqure 5.1, respectively.

f. Analog Deviation Sensitivity (SCS-483, para. 3.20). Table 5-1 shows all modules but one were lower than the specified 500 Hz/V. Allowable limits for this parameter will need to be specified.

g. Analog Deviation Linerity (SCS-483, para. 3.21). Table 5-1 shows that all modules were well within the specified 5%.

h. FSK Deviation (SCS-483, para. 3.20). The FSK deviation is tabulated in two ways in Table 5-1, as a positive and negative deviation from center frequency and as a total digital deviation. Since no center frequency was recorded for the pre-aging tests only total deviation is provided.

i. Frequency Adjustment Range (SCS-483, para. 3.17). The specification requires a minimum of $\pm$ 5 ppm of nominal frequency for a 25K potentiometer. Table 5-1 shows adjustment ranges relative to the center of the tuning range. Data indicate that there is more than sufficient adjustment range to accommodate crystal manufacturing tolerance and aging.

5.3.2 Transient Frequency Stability Tests (SCS-483, para. 3.13)

Table 5-2 summarizes the transient frequency stability test data. Difficulties were encountered in making this measurement because of the tendency of the modules to oscillate in a spurious mode. These spurious oscillations, of variable duration occurred at approximately 5 to 7 MHz, depending on the loading and on the individual modules. It was found that by using the 50 ohm input to the HP5360A computing counter, but with the coaxial cable shield not connected at the counter end, the spurious oscillations would stop in most cases before 10 ms. The circuit would then oscillate in the normal mode, controlled by the crystal, and the transient stability measurement could be made.

Table 5-2. Transient Frequency Stability-Data Summary

TCVCXO S/N No.	Pre-Aging Test Δf (Hz)
1	Note 1
2	0
3	Note 2
4	+1
5	O (Note 3)
7	Note 4
8	+1

Notes:

1. Spurious oscillation at 5 MHz prevented measurement of transient stability.

2. Spurious oscillation.

3. Spurious oscillations lasted approximately 3 to 8 ms. Initial frequency measurement made from 10 to 20 ms.

4. Spurious oscillation at 7 MHz prevented measurement of transient stability.

Where data could be taken, it was found that the variation from 10 to 100 ms was 1 Hz at most. A 10 ms counting period was required by the HP5360A to achieve a resolution of 1 Hz, so the frequency was actually measured during the interval from 5 to 15 ms and again from 90 to 100 ms. The former was then subtracted from the latter to give the Δf recorded in Table 5.2. The results are seen to be well within the specification limit of 10 Hz.

5.3.3 Temperature Tests (SCS-483, para. 3.10).

Reference to the individual temperature plots in the Appendix shows that only one of the units, S/N 7, is entirely within the limits of $\pm$ 2 ppm over the range from -40° to +75°C. The general cubic shape of the crystal is still discernible in the module curves, which suggests that there is insufficient gain for the temperature compensation voltage channel. Also, the generally large negative slope below -20°C suggests that either the "thermometer" or the diode function generator is inadequate in this region.

5.4 Aging (SCS-483, para. 3.14)

Of the seven TCVCXO modules which underwent final pre-aging electrical tests, five units were submitted for aging. Two units, S/N 1 and S/N 3 were not put into aging because of their inadequate temperature compensation circuits. The aging process will continue into the next quarterly report period, and the results will be reported in Quarterly Progress Report No. 5.

6.0 PROGRESS ON 15-LOT SAMPLES

6.1 Parts and Materials Procurement

Chip-and-wire components were ordered for the 15-lot modules to replace the beam-lead devices used in the 10-lot modules.

6.2 Fabrication of Substrates

The redesigned VCXO substrates which utilize the internal crystal pad location for the 9-volt regulator were fabricated for the 15-lot modules. The TCFG screens, previously redesigned, were used to fabricate the TCFG sections for the 15-lot effort.

7.0 CONCLUSIONS

The major accomplishments during the fourth quarter of this program have been the completion of test procedures for use during module production, completion of the first engineering samples of the TCVXO modules for the 10-lot submission, completion of pre-aging electrical testing of the 10-lot engineering samples, and initiation of aging for modules passing the pre-aging tests. Based on experience with the 10-lot modules, redesign of both TCFG and VCXO substrates has been completed. Effort is continuing on the various trimming problems encountered in this program, including modification of the laser trimming holding fixture to overcome the spurious oscillation problem, and on the hermetic sealing problem.

8.0 PROGRAM FOR NEXT QUARTER

During the next quarter, aging of the 10-lot TCVCXO engineering modules will be completed, and these modules will be subjected to the required post-aging functional testing. TCFG and VCXO screening, passive trim and assembly will be completed for the 15-lot engineering samples. Documentation transfer and generation of source control documentation will be continued, as will the hermetic sealing study and experimentation.

APPENDIX A

IDENTIFICATION OF PERSONNEL

IDENTIFICATION OF PERSONNEL

The following Raytheon Equipment Development Laboratories professional personnel performed work on this program during the fourth quarter. The man- hours of work charged to the program by each individual is reported, as is the program contributions and technical background of each.

Charles T. Martin* (40 hours)	TCVCXO Engineering Phase Project Manager; also prepared engineering phase monthly technical reports and third quarterly report.
Leland Woodworth* (14 hours)	Prepared TCVCXO engineering phase monthly cost reports and supervised production control activity for TCVCXO parts and materials procurement.
Stanley Czerepak* (51 hours)	Accomplished layout redesign and artwork generation for TCFG and VCXO hybrid microcircuits.
Richard Bemis* (140 hours)	Performed testing of TCFG and VCXO hybrids and testing and aging of 10-lot modules.
Charles Morris* (314 hours)	Provided engineering assistance to production facility during 15-lot manufacturing start-up; participated in preparation of engineering phase monthly technical report and third quarterly report; designed resistor trim probe cards for redesigned hybrids; assisted in testing of TCFG and VCXO hybrids and TCVCXO modules.

Thomas Salzer** (33 hours)	Performed hermetic sealing of hybrid microcircuits for 10-lot modules.
Frank Cheriff*** (4 hours)	Supervised assembly of 10-lot modules.

* See first quarterly report for individual' s technical background.

** See second quarterly report for individual' s technical background.

*** See third quarterly report for individual' s technical background.

The above listed personnel were assisted by the following support functions at the level of effort indicated.

Q.C. Engineering	2 hours.
Q.C. Inspection	13 hours.
Production Control	26 hours.
Manufacturing (10-lot)	125 hours.
Drafting (artwork generation)	37 hours.
Environmental Testing	7 hours.
Supervision Administration	51 hours.
Miscellaneous	2 hours.

Total level of effort for this quarter was 1063 hours.

Major effort on the TCVCXO program was transferred during this quarter to the Raytheon Industrial Components Operation plant at Quincy, Massachusetts. The following ICO personnel participated in the program to the extent indicated:

Christos Alex (38 hours)	TCVCXO Program Manager. General supervision of the Quincy effort. B.S. Chemical Engineering. Senior Program Manager, Microelectronics, responsible for all production programs.
Kenneth Pilczak (55 hours)	TCVCXO Project Engineer, provided technical lead for program. Contributed to the production engineering effort. B.S.E.E.
John J. Queenan (12 hours)	Conducted resistor paste experiments and supervised laboratory effort in screening and assembly of first engineering samples. Engineering Specialist, supervises microelectronics laboratory.
John Senoski (88 hours)	Responsible for transfer of design to manufacturing, including documentation.

The above listed personnel were assisted by the following support functions at the level of effort indicated:

Engineering Laboratory Support	41 hours.
Drafting	144 hours.

Total level of effort for this quarter:

Equipment Development Laboratories	1063 hours.
Industrial Components Operation	376 hours.

APPENDIX B

PRE-AGING ELECTRICAL TEST DATA

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388 SHEET / REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. 1 FREQ. 21 MHz TEST Pre-Aging
TCFG NO. 10
VCXO NO. 3 XTAL NO. 51 . V @ 9V REG ________
V @ TP 1 ________
DATE: 6-28-77 BY. R.I. Bemis

TEST NO.	INPUTS SUPPLY	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input Pwr)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.	3.45	
2. (RF OUT.)	12	0	0	5	R_L: 1000Ω	1.5 VPP Min ~~Max~~	Rf Tp	1.10	
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L: 1000Ω	±0.25 PPM ±5.3 Hz	Rf Tp	20 999 200 201 197	-1.0 Hz -4.0
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	± 0.25 PPM ±5.3 Hz	Rf Tp	20 999 199 200 196	-1.0 Hz -4.0
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01, 1 khz	200 K	TP1	Cal: 1.037 0.513 Zin: 196 KΩ	
6. (Analog Freq.-Dev. & Dev. Lin.) f Adj. Range: 21 000 290 20 998 124 2166 ± 1083	12	~~0.75~~ .79 0.6 0.4 0.2 0.0 0.2 0.4 0.6 ~~0.75~~ .79	0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization (Mid Adj. Range)	356.3 to 393.7 -393.7 to -356.3	Rf	20 998 839 8 930 9 017 106 188 270 368 479 575	-349 -258 -171 -82 0 +82 +180 +291 +387 Average Sensitivity: 466 Hz/v
7. (Fsk. Dev.)	12	0	5 0	0	with Cntl in Anlg and Eanl 0V, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf	20 999 478 20 998 905	Total Deviation 573

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388	SHEET	REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. 2 — FREQ. 18 MHz — TEST Pre-Aging

TCFG NO. 8

VCXO NO. 21 — XTAL NO. 23 — V @ 9V REG ______

V @ TP 1 ______

DATE: 6-24-77 — BY. R. I. Bemis

TEST NO.	INPUTS SUPPLY	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input Pwr)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.	3.55	
2. (RF OUT.)	12	0	0	5	R_L:1000Ω	1.5 VPP Min ~~Max~~	Rf Tp	1.12	
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L:1000Ω	± 0.25 PPM ±4.5 Hz	Rf Tp	18 000 012 012 012	+0.0 Hz -0.0
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	± 0.25 PPM ±4.5 Hz	Rf Tp	18 000 014 012 011	+2.0 Hz -1.0
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01,1 khz	200 KΩ	TP1	Cal: 1.011 .485 Zin: 184 KΩ	
6. (Analog Freq.-Dev. & Dev. Lin.) 18 000 686 17 998 775 1911 ± 956	12	~~0.75~~ +.79 0.6 0.4 0.2 0.0 0.2 0.4 0.6 ~~0.75~~ -.79	0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization (Mid Adj. Range)	356.3 to 393.7 -393.7 to -356.3	Rf	17 999 375 467 558 645 727 817 919 024 119	-352 -260 -169 -82 0 +90 +192 +297 +392 Average Sensitivity: 471 Hz/v
7. (Fsk. Dev.)	12	0	5 ---- 0	0	with Cntl in Anlg and Eanl 0V, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf	18 000 027 17 999 454	Total Deviation: 573 Hz

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388 SHEET	REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. 3 FREQ. 18 MHz TEST Pre-Aging

TCFG NO. 12

VCXO NO. 14 XTAL NO. 22 V @ 9V REG ______

V @ TP 1 ______

DATE: 6-27-77 BY. R.I. Bemis

TEST NO.	INPUTS SUPPLY	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input Pwr)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.	3.40	
2. (RF OUT.)	12	0	0	5	R_L: 1000Ω	1.5 VPP ~~Max~~ Min	Rf Tp	1.0	
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L: 1000Ω	±0.25 PPM ±4.5 Hz	Rf Tp	17 999 510 510 508	+0.0 Hz -2.0
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	± 0.25 PPM ±4.5 Hz	Rf Tp	17 999 510 509 507	+1.0 Hz -2.0
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01,1 khz	200 K	TP1	Cal: 1.035 .509 Zin: 194 KΩ	
6. (Analog Freq.-Dev. & Dev. Lin.) {Adj. Range: 18 000 457 17 998 560 1897 ± 948	12	~~0.75~~ .79 0.6 0.4 0.2 0.0 0.2 0.4 0.6 ~~0.75~~ .79	.0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization (Mid Adj. Range)	356.3 to 393.7 -393.7 to -356.3	Rf	17 998 997 9 133 268 392 509 617 719 815 904	-512 -376 -241 -117 0 +108 +210 +306 +395 Average Sensitivity: 574 Hz/v
7. (Fsk. Dev.)	12	0	5 0	0	with Cntl in Anlg and Eanl 0V, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf	17 999 830 ~~17 999 830~~ 17 999 118	Total Deviation: 712 Hz

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388 SHEET	REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. 4 FREQ. 18 MHz TEST Pre-Aging
TCFG NO. 3
VCXO NO. 27 XTAL NO. 29 V @ 9V REG 9.003
V @ TP 1 ______

DATE: 6-28-77 BY. R.I. Bemis

TEST NO.	INPUTS SUP'Y	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input P'c)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.	3.45	
2. (RF OUT.)	12	0	0	5	R_L: 1000Ω	1.5 VPP ~~Max~~ Min	Rf Tp	1.20	
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L: 1000Ω	± 0.25 PPM ± 4.5 Hz	Rf Tp	17 999 409 409 407	0 Hz -2
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	± 0.25 PPM ± 4.5 Hz	Rf Tp	17 999 411 409 408	+2 Hz -1
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01,1 khz	200 K	TP1	Cal: 1.036 Zin: 0.499 186 kΩ	
6. (Analog Freq.-Dev. & Dev. Lin.) f Adj. Range: 18 000 265 17 998 555 1710 ± 855	12	~~0.75~~ .79 0.6 0.4 0.2 0.0 0.2 0.4 0.6 ~~0.75~~ .79	0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization (Mid Adj. Range)	356.3 to 393.7 -393.7 to -356.3	Rf	17 999 031 130 229 322 410 493 572 656 747	-379 -280 -181 -88 0 +83 +162 +246 +337 Average Sensitivity: 453 Hz/v
7. (Fsk. Dev.)	12	0	5 --- 0	0	with Cntl in Anlg and Eanl OV, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf	17 999 669 17 999 122	Total Deviation: 547 Hz

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388	SHEET	REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. 5 FREQ. 18 MHz TEST Pre-Aging
TCFG NO. 4
VCXO NO. 10 XTAL NO. 2 V @ 9V REG ______
V @ TP 1 ______

DATE: 6/28/77 BY. R.I. Bemis

TEST NO.	INPUTS SUP'Y	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input P'r)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.	3.20	
2. (RF OUT.)	12	0	0	5	R_L:1000Ω	1.5 VPP Min ~~Max~~	Rf Tp	1.12	
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L:1000Ω	± 0.25 PPM ± 4.5 Hz	Rf Tp	17 999 604 604 603	0 Hz -1
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	± 0.25 PPM ± 4.5 Hz	Rf Tp	17 999 605 604 602	+1 Hz -2 Hz
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01,1 khz	200 K	TP1	Cal: 1.035 .505 Zin: 191 KΩ	
6. (Analog Freq.-Dev. & Dev. Lin.) f Adj. Range: 18 000 678 17 998 735 1943 ± 974	12	~~0.75~~ .79 0.6 0.4 0.2 0.0 0.2 0.4 0.6 ~~0.75~~ .79	0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization (Mid Adj. Range)	356.3 to 393.7 -393.7 to -356.3	Rf	17 999 214 316 417 513 603 688 769 848 932	-389 -287 -186 -90 0 +85 +166 +245 +329 Average Sensitivity: 454 Hz/v
7. (Fsk. Dev.)	12	0	5 0	0	with Cntl in Anlg and Eanl 0V, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf	17 999 859 17 999 305	Total Deviation: 504 Hz

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388	SHEET	REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. 7 FREQ. 18 MHz TEST Pre-Aging
TCFG NO. 6
VCXO NO. 9 XTAL NO. 20 V @ 9V REG
V @ TP 1

DATE: 6-28-77 BY. R.I. Bemis

TEST NO.	INPUTS SUP'Y	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input P'r)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.	3.50	
2. (RF OUT.)	12	0	0	5	R_L:1000Ω	1.5 VPP ~~Max~~ Min	Rf Tp	1.20	
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L:1000Ω	± 0.25 PPM ± 4.5 Hz	Rf Tp	17 999 635 635 634	0 Hz -1 Hz
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	± 0.25 PPM ± 4.5 Hz	Rf Tp	17 999 637 635 633	+2 Hz -2 Hz
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01,1 khz	200 K	TP1	Cal: 1.036 .503 Zin: 189 KΩ	
6. (Analog Freq.-Dev. & Dev. Lin.) f Adj. Range: 18000 656 17998 615 2041 ± 1022	12	~~0.75~~ .79 0.6 0.4 0.2 0.0 0.2 0.4 0.6 ~~0.75~~ .79	.0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization (Mid Adj. Range)	356.3 to 393.7 -393.7 to -356.3	Rf	17 999 281 373 465 552 635 716 812 914 008	-354 -262 -170 -83 0 +81 +177 +279 +373 Average Sensitivity: 460 Hz/v
7. (Fsk. Dev.)	12	0	5 0	0	with Cntl in Anlg and Eanl 0V, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf	17 999 928 17 999 370	Total Deviation: 558 Hz

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388 SHEET	REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. 8　　FREQ. 18 MHz　　TEST Pre-Aging
TCFG NO. 7　　XTAL NO. 24　　V @ 9V REG ______
VCXO NO. 23　　V @ TP 1 ______

DATE: 6-28-77　　BY. R. I. Bemis

TEST NO.	INPUTS SUP'Y	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input P'r)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.	3.45	
2. (RF OUT.)	12	0	0	5	R_L: 1000Ω	1.5 VPP ~~Max~~ Min	Rf Tp	1.20	
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L: 1000Ω	±0.25 PPM ±4.5 Hz	Rf Tp	17 999 604 604 604	0 Hz 0
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	± 0.25 PPM ±4.5 Hz	Rf Tp	17 999 606 604 603	+2 Hz -1 Hz
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01,1 khz	200 K	TP1	Cal: 1.036 .500 Zin: 187KΩ	
6. (Analog Freq.-Dev. & Dev. Lin.) f Adj. Range: 18 000 578 17 998 630 1948 ± 974	12	~~0.75~~ .79 0.6 0.4 0.2 0.0 0.2 0.4 0.6 ~~0.75~~ .79	0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization (Mid Adj. Range)	356.3 to 393.7 -393.7 to -356.3	Rf	17 999 253 345 436 523 605 685 776 875 967	-352 -260 -169 -82 0 +80 +171 +270 +362 Average Sensitivity: 452 Hz/v
7. (Fsk. Dev.)	12	0	5 0	0	with Cntl in Anlg and Eanl 0V, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf	17 999 877 17 999 328	Total Deviation: 549 Hz

TCVCXO MODULES, 10 LOT S/N 1

TRANSIENT FREQUENCY STABILITY (INITIAL TURN ON)

(Pgh. 3.13, SCS-483)

	PRE-AGING	POST-AGING
f_0 (Initial Steady State)		
f_1 (Avg., 5 to 15 ms)		
f_2 (Avg., 90 to 100 ms)		
Δf ($f_2 - f_1$)		
f_3 (Final Steady State)		

REMARKS:

Oscillates in spurious mode at approx. 5 MHz.

TCVCXO MODULES, 10 LOT S/N 2

TRANSIENT FREQUENCY STABILITY (INITIAL TURN ON)

(Pgh. 3.13, SCS-483)

	PRE-AGING	POST-AGING
f_0 (Initial Steady State)	17,999,555	
f_1 (Avg., 5 to 15 ms)	- - 554	
f_2 (Avg., 90 to 100 ms)	- - 554	
Δf $(f_2 - f_1)$	0	
f_3 (Final Steady State)	- - 556	

REMARKS:

TCVCXO MODULES, 10 LOT S/N 4

TRANSIENT FREQUENCY STABILITY (INITIAL TURN ON)

(Pgh. 3.13, SCS-483)

	PRE-AGING	POST-AGING
f_0 (Initial Steady State)	18,777,302	
f_1 (Avg., 5 to 15 ms)	- 300	
f_2 (Avg., 90 to 100 ms)	- 301	
Δf $(f_2 - f_1)$	+1	
f_3 (Final Steady State)	- 303	

REMARKS:

TCVCXO MODULES, 10 LOT S/N 5

TRANSIENT FREQUENCY STABILITY (INITIAL TURN ON)

(Pgh. 3.13, SCS-483)

	PRE-AGING	POST-AGING
f_0 (Initial Steady State)	18,000,573	
f_1 (Avg., 5 to 15 ms)	- - 572	
f_2 (Avg., 90 to 100 ms)	- - 572	
Δf $(f_2 - f_1)$	0	
f_3 (Final Steady State)	- - 572	

REMARKS:

Does not turn on reliably in 5 ms. f_1 measured from 10 to 20 ms.

TCVCXO MODULES, 10 LOT S/N 7

TRANSIENT FREQUENCY STABILITY (INITIAL TURN ON)

(Pgh. 3.13, SCS-483)

	PRE-AGING	POST-AGING
f_0 (Initial Steady State)	17,199,377	
f_1 (Avg., 5 to 15 ms)		
f_2 (Avg., 90 to 100 ms)		
Δf (f_2 - f_1)		
f_3 (Final Steady State)		

REMARKS:

Spurious mode of oscillation @ approx. 7 MHz prevented measurement of transient stability.

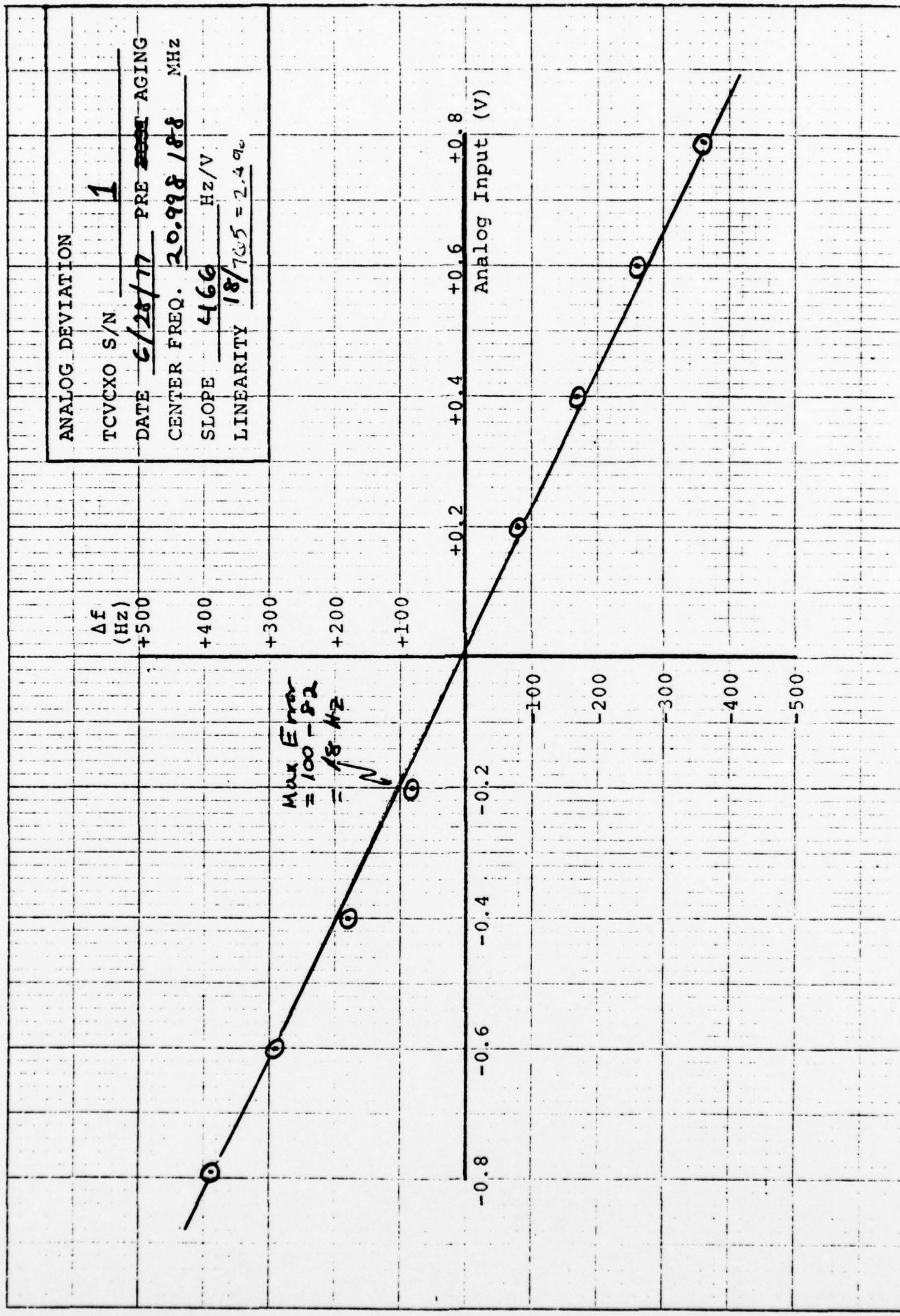
TCVCXO MODULES, 10 LOT   S/N 8

TRANSIENT FREQUENCY STABILITY (INITIAL TURN ON)

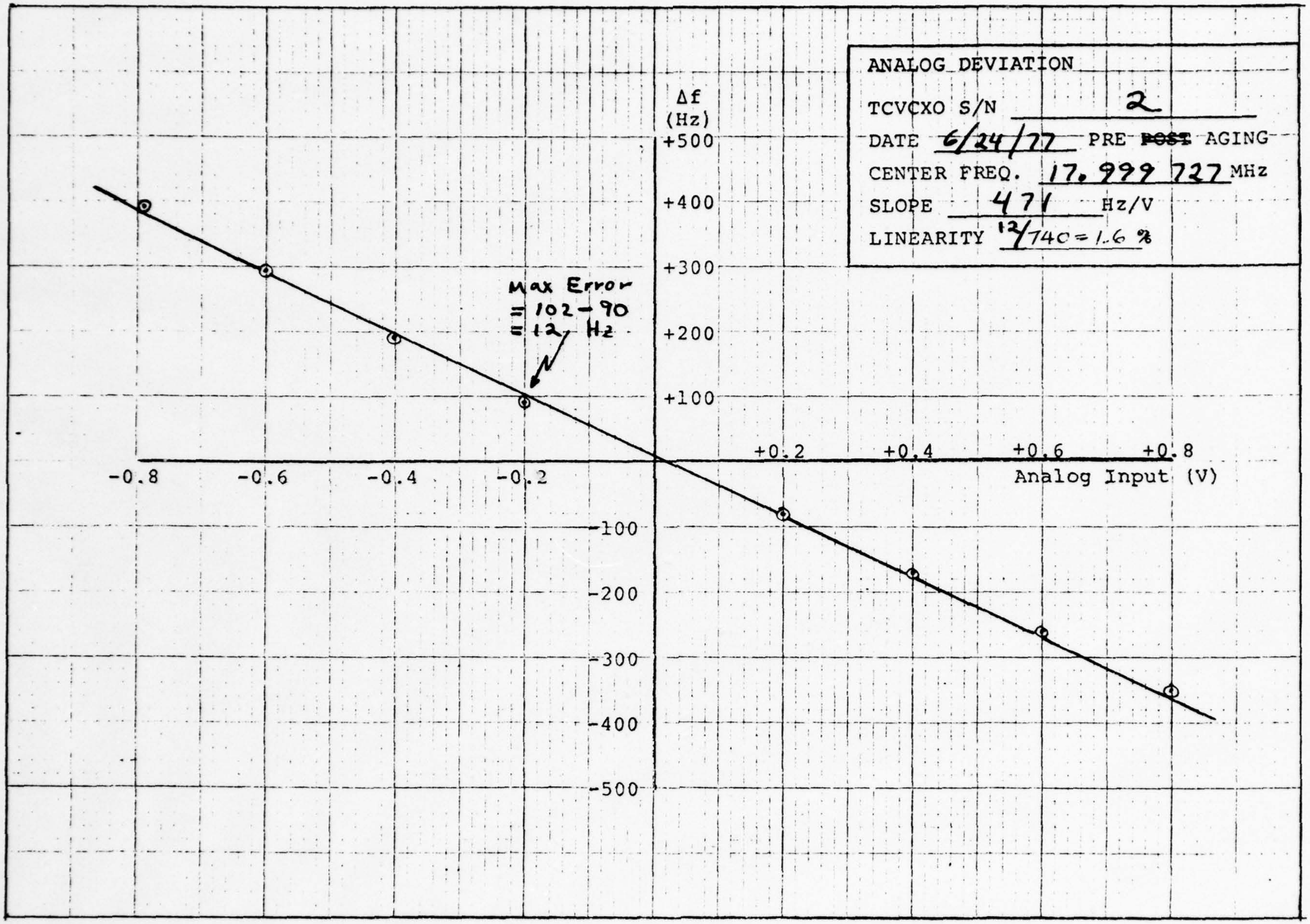
(Pgh. 3.13, SCS-483)

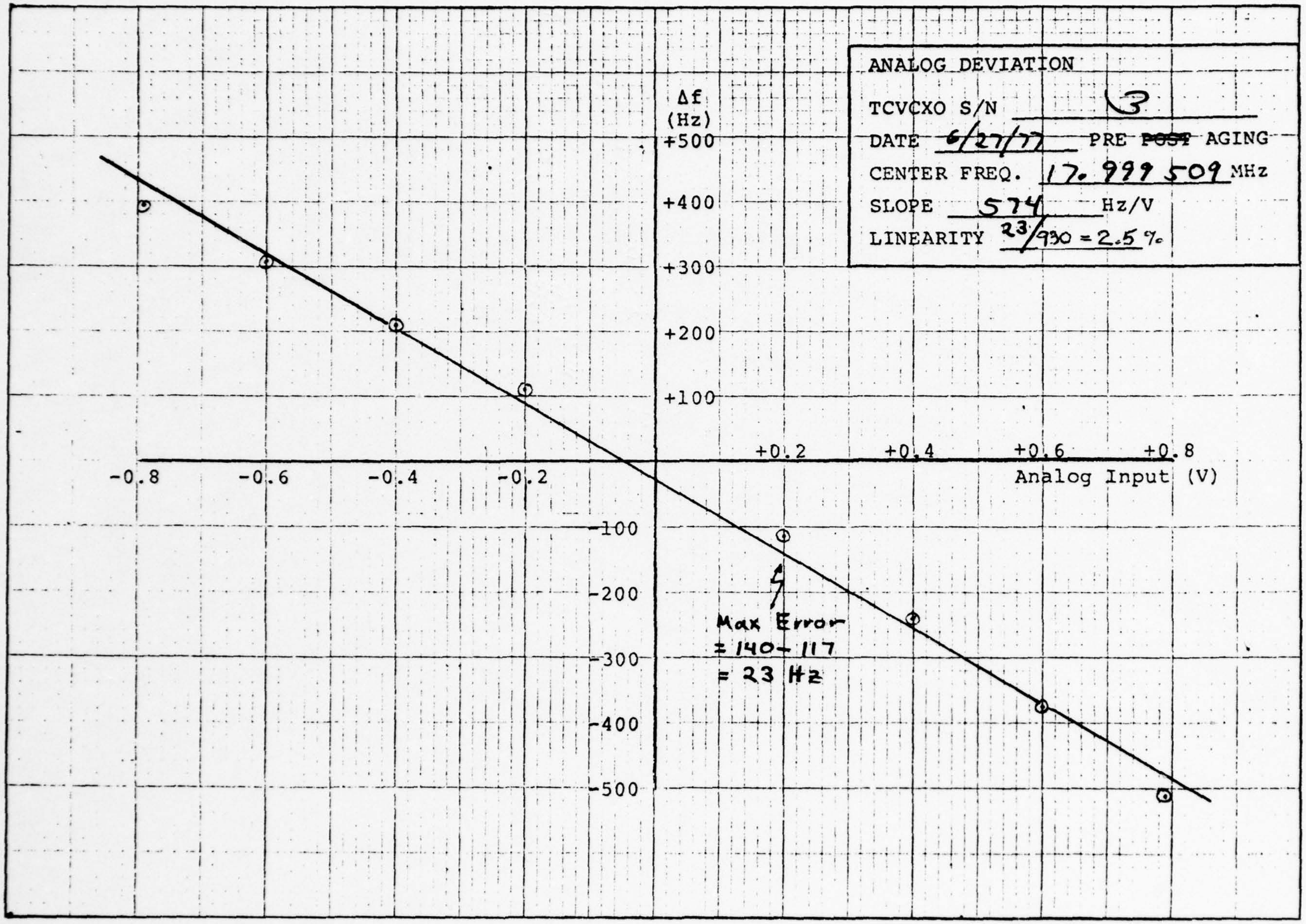
	PRE-AGING	POST-AGING
f_0 (Initial Steady State)	17,799,341	
f_1 (Avg., 5 to 15 ms)	347	
f_2 (Avg., 90 to 100 ms)	348	
Δf $(f_2 - f_1)$	+1	
f_3 (Final Steady State)	348	

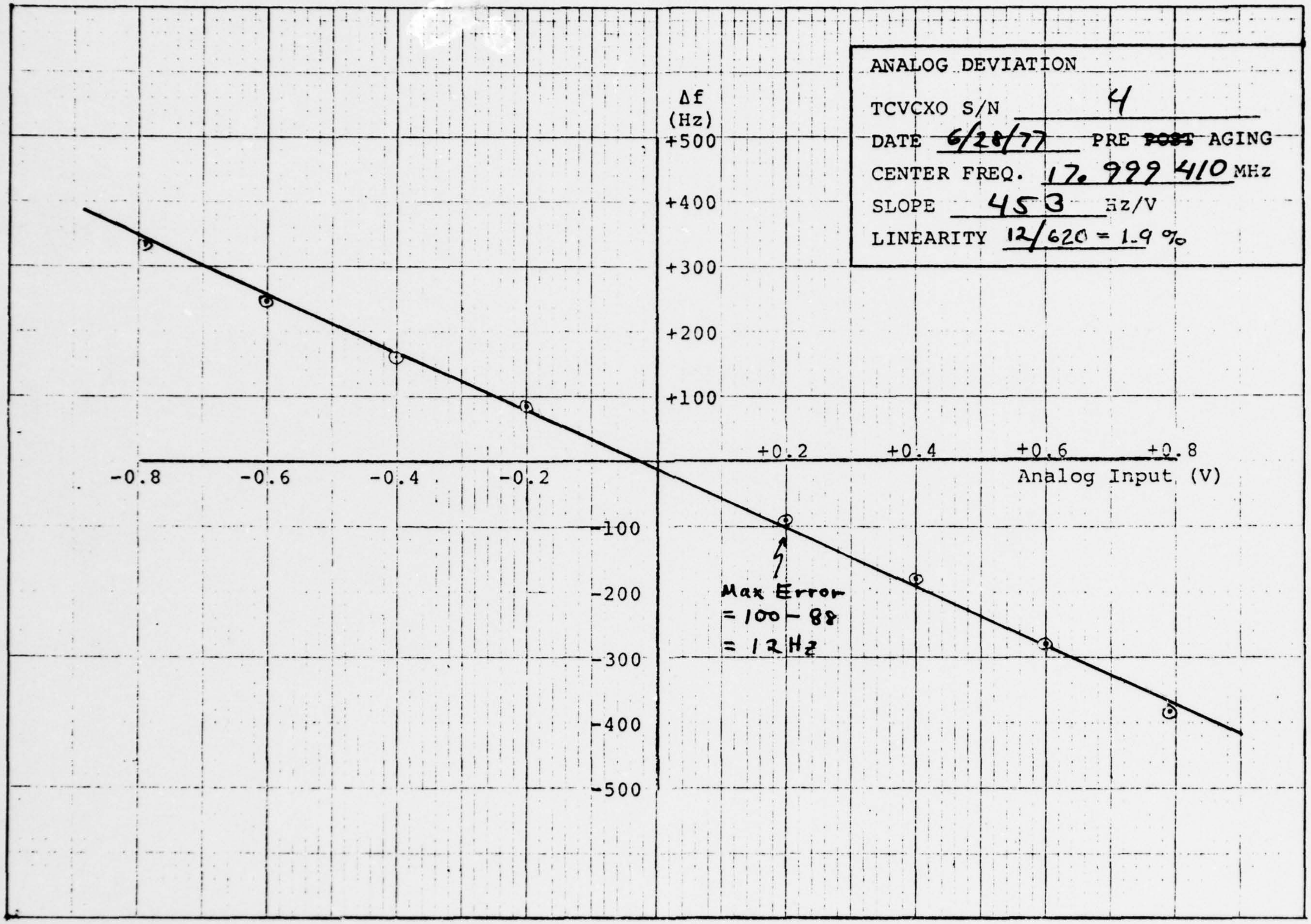
REMARKS:


ANALOG DEVIATION
TCVCXO S/N 1
DATE 6/28/77 PRE ~~POST~~ AGING
CENTER FREQ. 20.998 188 MHz
SLOPE 466 Hz/V
LINEARITY 18/765 = 2.4%
Δf (Hz)
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
-0.8
-0.6
-0.4
-0.2
+0.2
+0.4
+0.6
+0.8
Analog Input (V)
Max Error = 100 - 82 = 18 Hz

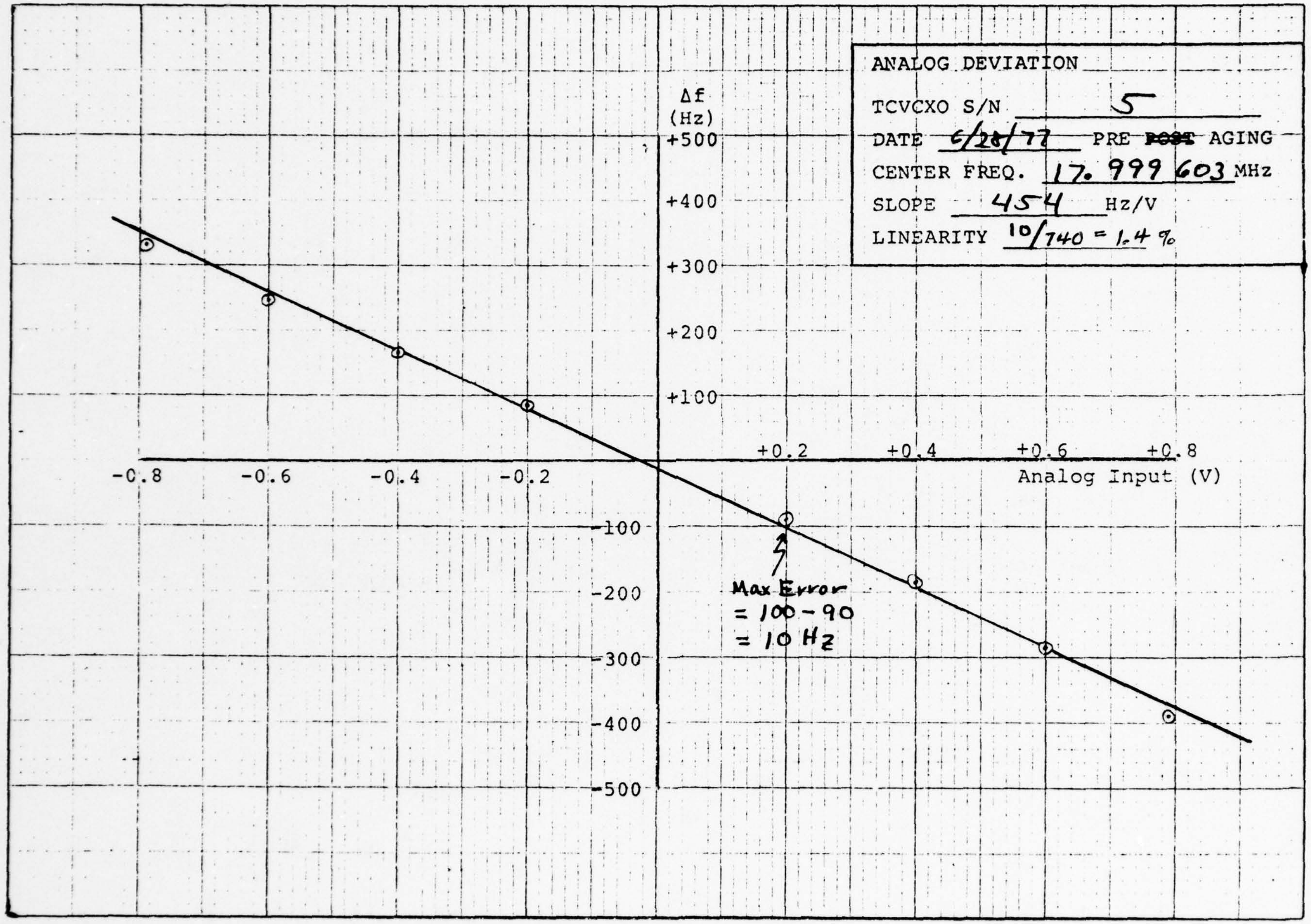
46 0782

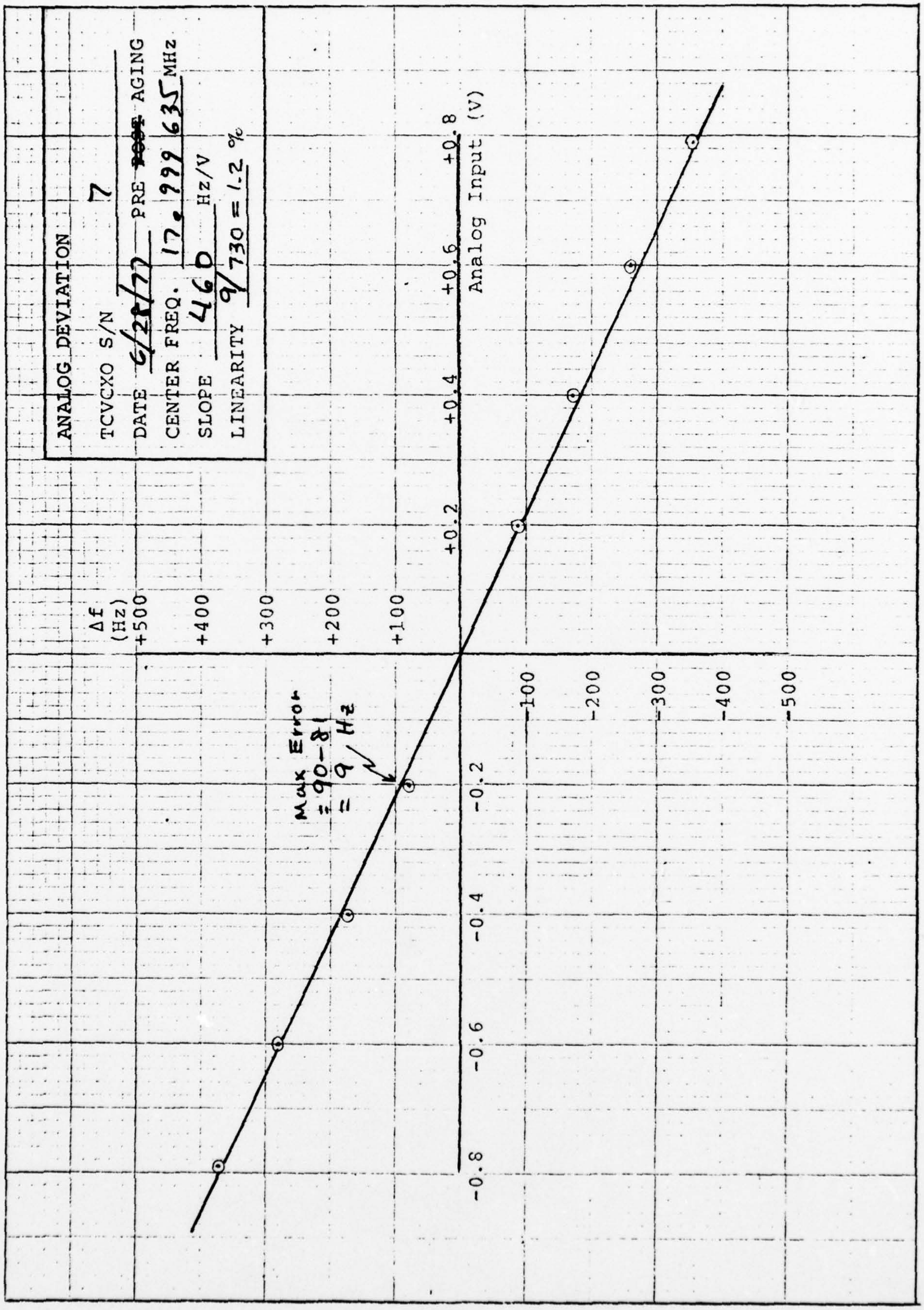

ANALOG DEVIATION
TCVCXO S/N 2
DATE 6/24/77 PRE ~~POST~~ AGING
CENTER FREQ. 17.999 727 MHz
SLOPE 471 Hz/V
LINEARITY 12/740 = 1.6 %
Δf (Hz)
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
-0.8
-0.6
-0.4
-0.2
+0.2
+0.4
+0.6
+0.8
Analog Input (V)
Max Error = 102 − 90 = 12 Hz


ANALOG DEVIATION
TCVCXO S/N 3
DATE 6/27/77 PRE ~~POST~~ AGING
CENTER FREQ. 17.999 509 MHz
SLOPE 574 Hz/V
LINEARITY 23/930 = 2.5 %
Δf (Hz)
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
-0.8
-0.6
-0.4
-0.2
+0.2
+0.4
+0.6
+0.8
Analog Input (V)
Max Error
= 140 - 117
= 23 Hz

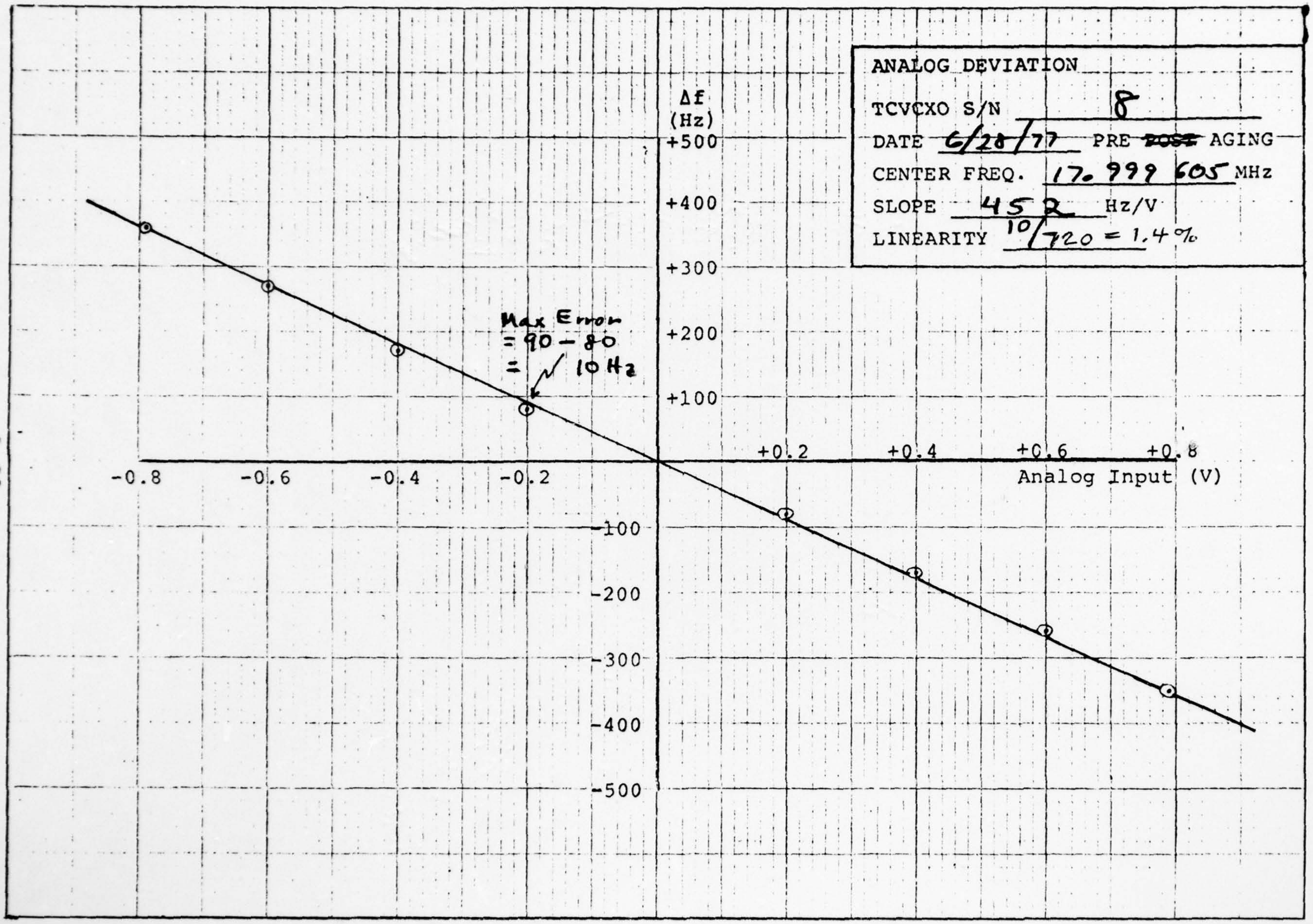

ANALOG DEVIATION
TCVCXO S/N 4
DATE 6/28/77 PRE ~~POST~~ AGING
CENTER FREQ. 17.999 410 MHz
SLOPE 453 Hz/V
LINEARITY 12/620 = 1.9 %
Δf (Hz)
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
-0.8
-0.6
-0.4
-0.2
+0.2
+0.4
+0.6
+0.8
Analog Input (V)
Max Error
= 100 - 88
= 12 Hz

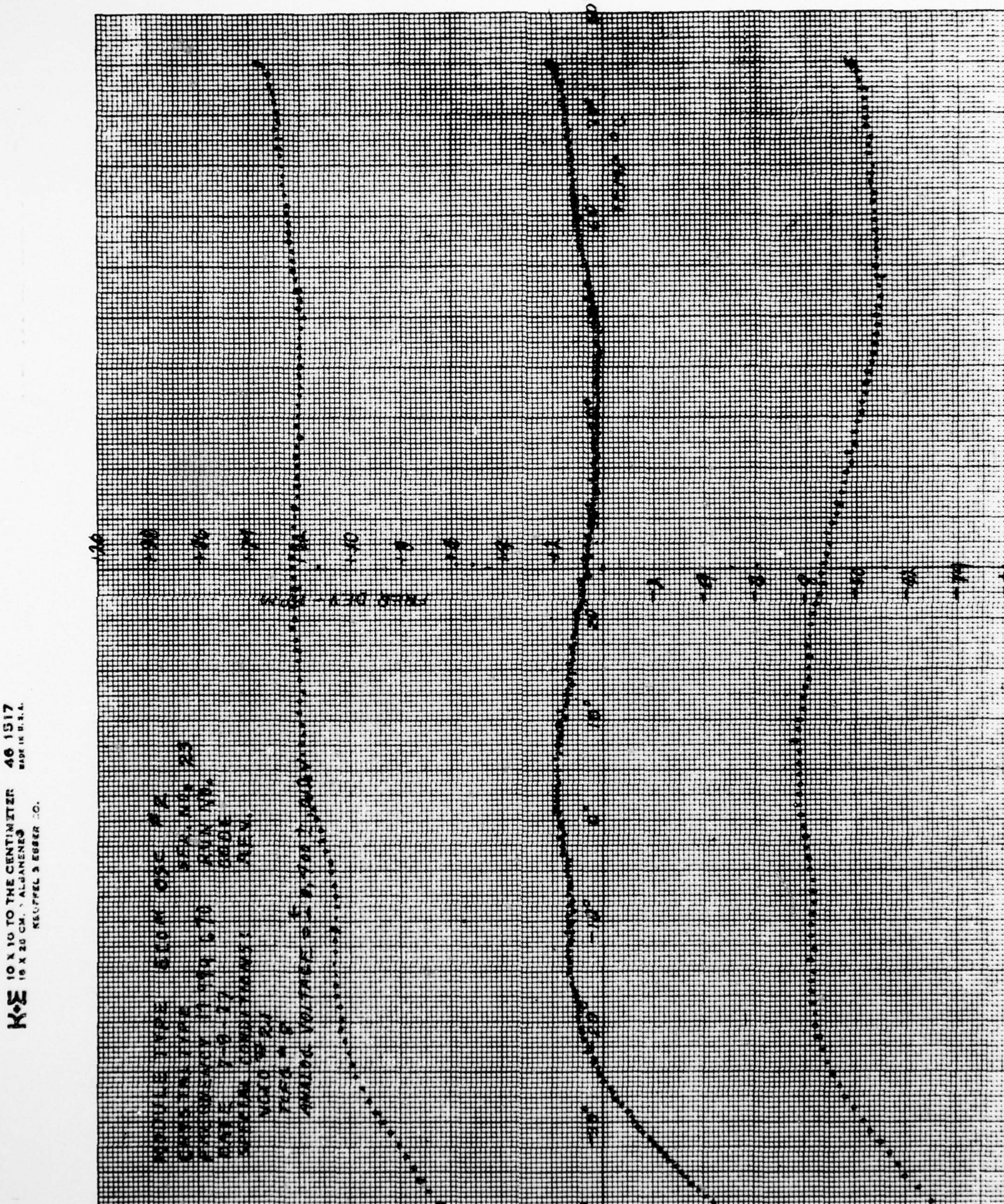
46 0782

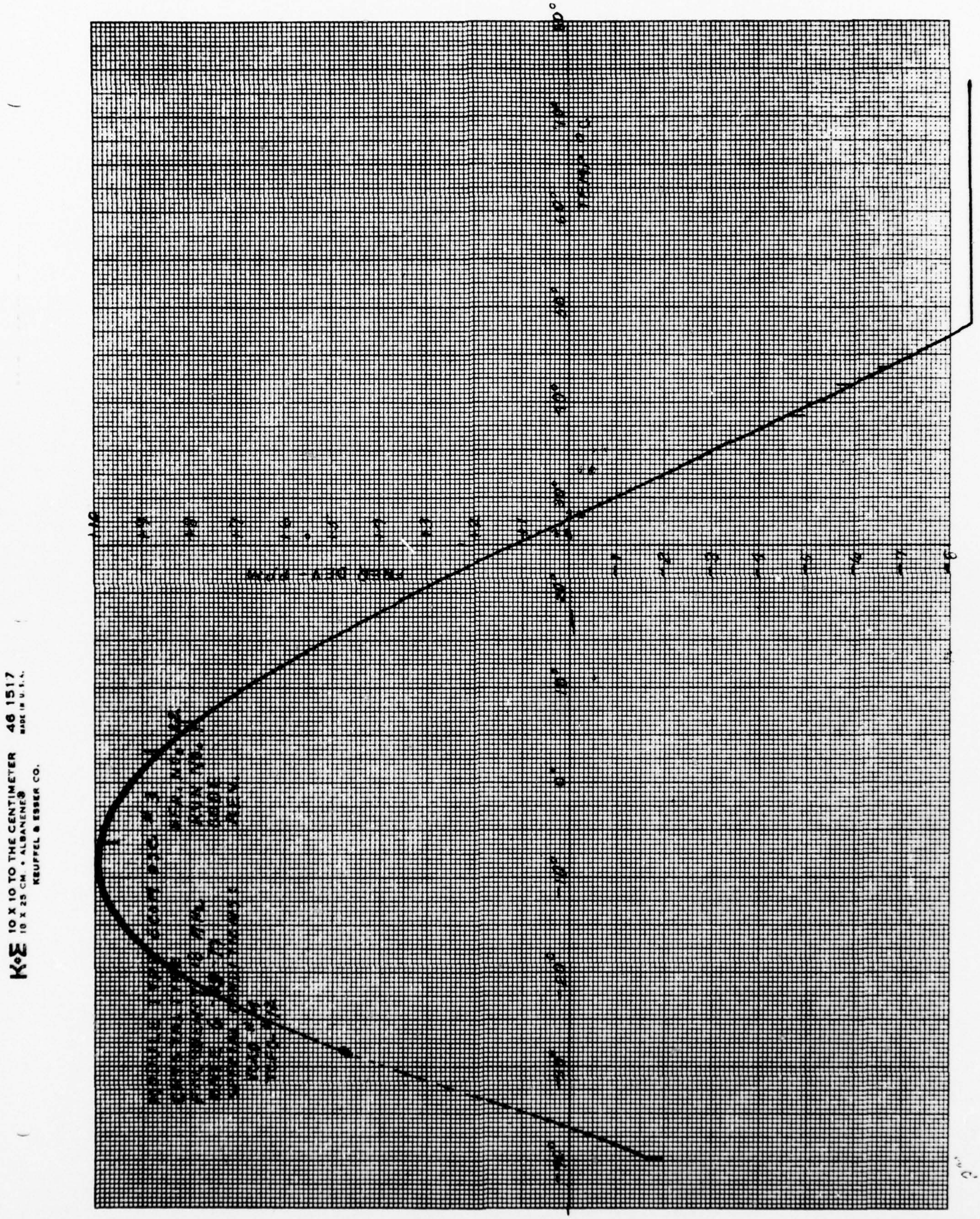

ANALOG DEVIATION
TCVCXO S/N 5
DATE 6/28/77 PRE ~~POST~~ AGING
CENTER FREQ. 17. 999 603 MHz
SLOPE 454 Hz/V
LINEARITY 10/740 = 1.4 %
Δf
(Hz)
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
-0.8
-0.6
-0.4
-0.2
+0.2
+0.4
+0.6
+0.8
Analog Input (V)
Max Error
= 100 - 90
= 10 Hz

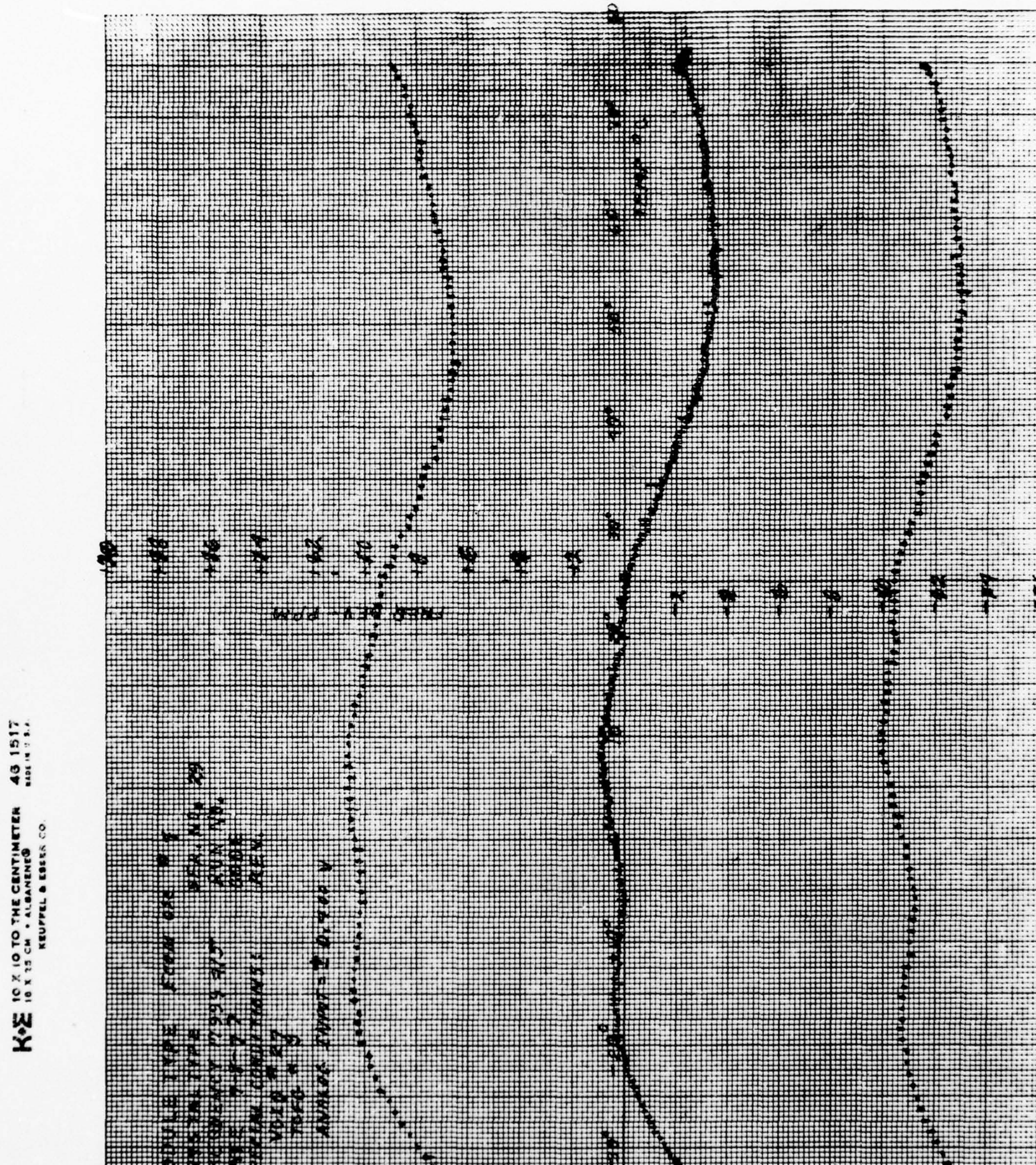

ANALOG DEVIATION
TCVCXO S/N 7
DATE 6/28/77 PRE ~~POST~~ AGING
CENTER FREQ. 17.999 635 MHz
SLOPE 460 Hz/V
LINEARITY 9/730 = 1.2 %
Δf
(Hz)
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
-0.8
-0.6
-0.4
-0.2
+0.2
+0.4
+0.6
+0.8
Analog Input (V)
Max Error
= 90-81
= 9 Hz

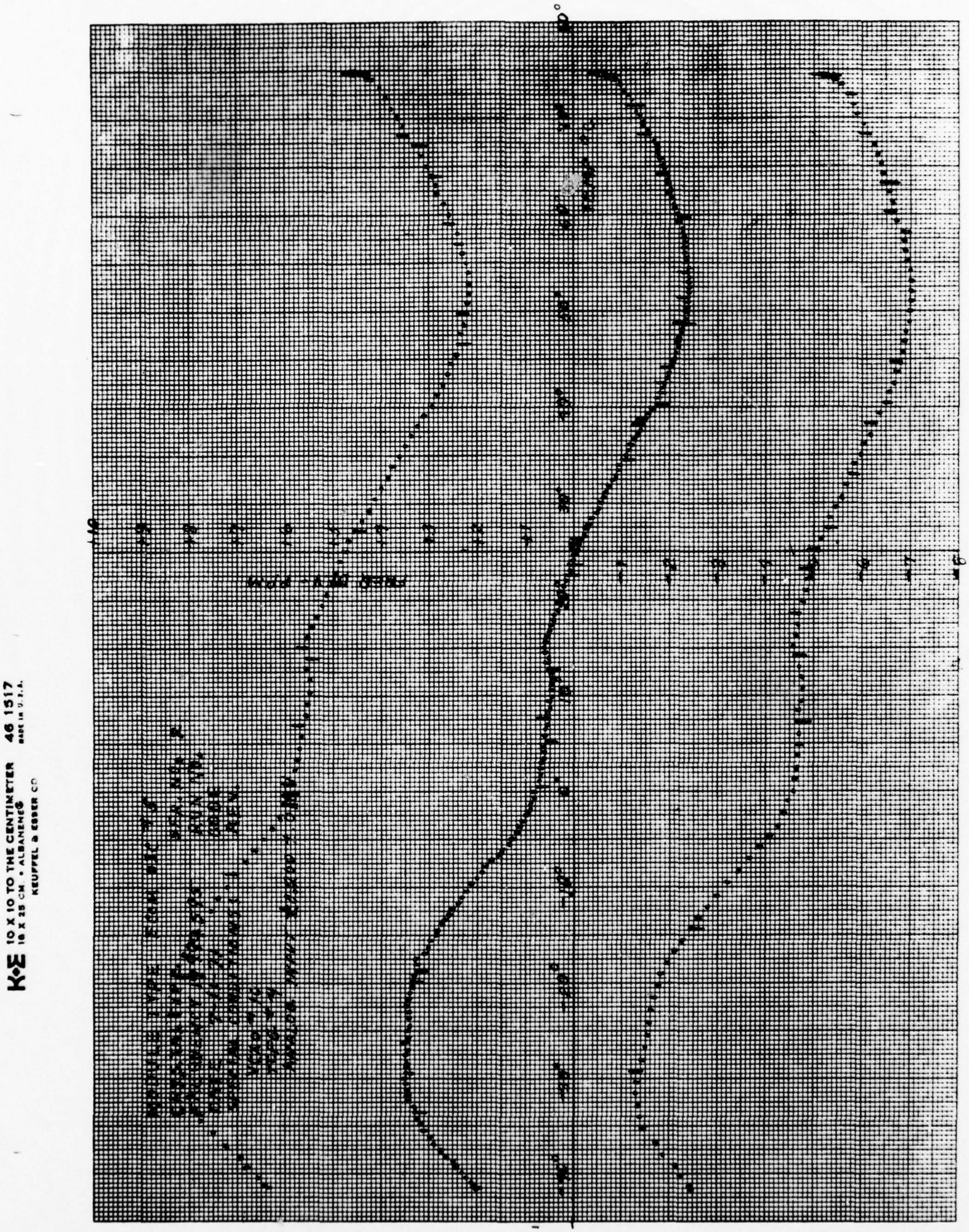
46 0782

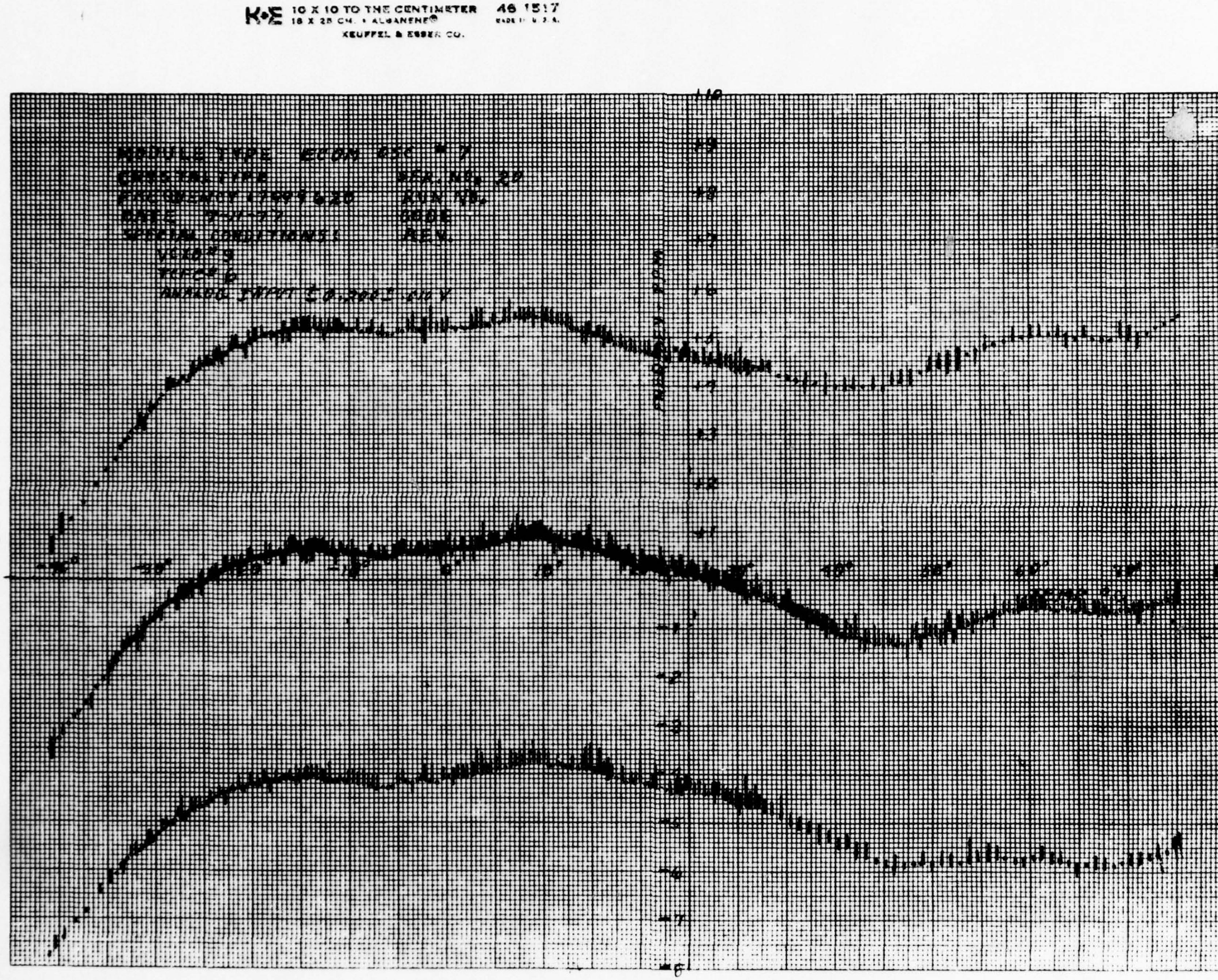

ANALOG DEVIATION
TCVCXO S/N 8
DATE 6/28/77 PRE ~~POST~~ AGING
CENTER FREQ. 17.999 605 MHz
SLOPE 452 Hz/V
LINEARITY 10/720 = 1.4%
Δf (Hz)
+500
+400
+300
+200
+100
-100
-200
-300
-400
-500
-0.8
-0.6
-0.4
-0.2
+0.2
+0.4
+0.6
+0.8
Analog Input (V)
Max Error = 90 − 80 = 10 Hz


K+E 10 X 10 TO THE CENTIMETER 18 X 25 CM. ALBANENE 46 1517 MADE IN U.S.A.
KEUFFEL & ESSER CO.
MODULE TYPE
SER. NO. 23
DATE 7-8-77
SPECIAL CONDITIONS:
FREQ DEV - PPM
TEMP °C

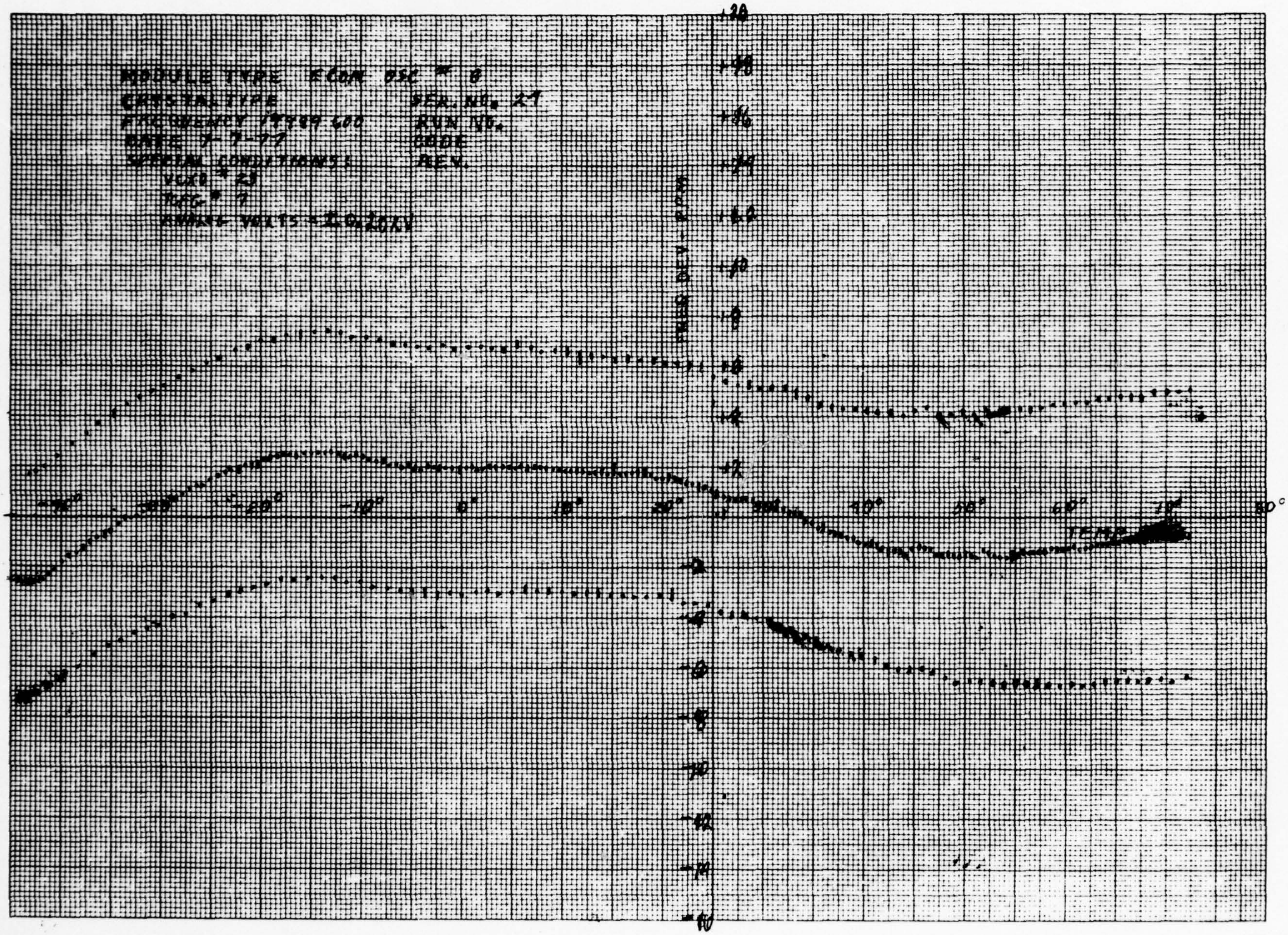



K+E 10 X 10 TO THE CENTIMETER 46 1517
18 X 25 CM • ALBANENE®
KEUFFEL & ESSER CO.
MADE IN U.S.A.
MODULE TYPE
VOID # 27





K+E 10 X 10 TO THE CENTIMETER 46 1517
18 X 25 CM. ALBANENE®
KEUFFEL & ESSER CO.
SER. NO. 20
RUN NO.
CODE
REV.
+10
-10
0°


MODULE TYPE ECOM OSC # 8
CRYSTAL TYPE
SER. NO. 27
FREQUENCY 14989 600
RUN NO.
DATE 7-7-77
CODE
SPECIAL CONDITIONS:
REV.
VCXO # 23
TCG # 7
ANALOG VOLTS = 1.0/2.0KV
FREQ. DEV. - PPM
TEMP.
80°

APPENDIX I

TRS 31388
TCVCXO MODULE FUNCTIONAL TEST

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388 SHEET 1 OF 9 REV -

TYPE OF SPEC

TEST REQUIREMENTS SPECIFICATION

TITLE OF SPEC

TCVCXO MODULE FUNCTIONAL TEST

FUNCTION	APPROVED	DATE	FUNCTION	APPROVED	DATE
WRITER	C. Morris	3-7-77			

REVISIONS

CHK	DESCRIPTION	REV	CHK	DESCRIPTION	REV

REVISION									
SHEET NO.									
REV STATUS OF SHEETS	REVISION	-	-	-	-	-	-	-	-
	SHEET NO.	1	2	3	4	5	6	7	8

10-2742 (6-72) VELLUM PRINTED IN U.S.A.

1.0 SCOPE

This specification applies to the testing of the temperature-compensated, voltage controlled crystal oscillator (TCVCXO). It applies to the testing of the TCVCXO module assembly, the encapsualated TCVCXO module and the functional pairing of individual TCFG and VCXO hybrid microcircuits, prior to assembling these hybrids into a module. TCVCXO modules satisfying this specification will conform to the requirements of USAECOM Technical Requirements SCS-483, dated 17 January 1975, Sections 3 and 4, and Amendment 3 thereto, dated 14 June 1976, with the following exceptions. The transient frequency stability, frequency-temperature stability and aging requirements are covered by separate specifications.

2.0 APPLICABLE DOCUMENTS

SCS-483	Oscillator, Crystal, Temperature Compensated, Voltage Controlled (TCVCXO), 17 MHz to 22 MHz, Hermetic Seal
MIL-O-55310	Oscillators, Crystal, General Specification
31380	TCVCXO Module
31383	TCVCXO Electrical Schematic
31355	Substrate-Component Assembly, VCXO Hybrid
31357	Substrate-Component Assembly, TCFG Hybrid
31351-2,3	Final Assembly, VCXO Hybrid
31351-5	Final Assembly, TCFG Hybrid
31382	Electrical Test Flow Plan, TCVCXO Module

3.0 REQUIREMENTS

3.1 Test Equipment

Equipment Item	Description
1. Audio Oscillator	HP 200 CD or equivalent
2. Power supply	Harrison 855B or equivalent
3. Power supply	Harrison 855B or equivalent
4. Digital voltmeter	Fluke 8000A or equivalent
5. Oscilloscope	Tektronix 547 or equivalent
6. Frequency counter	HP 5360 or equivalent
7. Current probe and meter	HP 428 or equivalent
8. Patch Cords	

Equipment Item	Description
9. TCVCXO Functional Test Box	31366
10. TCVCXO Substrate-Component Assembly Functional Test Fixture	31373
11. Probe Card, Electrical Test	31372

3.2 Test Set-Up

The test equipment set-up shall be as shown in Figure 1. When testing individual TCFG and VCXO hybrids, paired together, the Functional Test Fixture is required; after assembly of the hybrids into a module, this fixture is not used in the set-up.

3.3 Functional Test

3.3.1 While performing this test fill in the TCVCXO Functional Tests Form (Figure 2).

3.3.2 Turn power off.

3.3.3 If testing a module, plug module into connector; if not, load hybrids and matching crystal (if required) into Functional Test Fixture.

3.3.4 Place power switch to 12V, Analog to 0V, FSK to $-\Delta$, Control to Analog, RF Load to 1000 ohms.

3.3.5 Turn power on.

3.3.6 Test No. 1, Input power.

3.3.6.1 Observe module current drain at the current loop. Record the value measured on the test form. The current must be less than 4.12 MA.

3.3.7 Test No. 2, RF Output.

3.3.7.1 Observe the RF Output at the RF test point with the oscilloscope. Record the peak to peak voltage. The value must be greater than 1.5 volt peak to peak.

3.3.8 Test No. 3, Frequency - Voltage stability.

3.3.8.1 Observe the frequency of the TCVCXO. After it has stabilized to within ± 0.5 HZ, record the frequency in the 12 volt line,

3.3.8.2 Switch the power to + 10 VDC.

3.3.8.3 Record the frequency in the +10 volt line.

3.3.8.4 Switch the power to + 15 VDC.

3.3.8.5 Record the frequency in the + 15 volt line.

3.3.8.6 To be acceptable the frequency differences between Steps 3.3.8.1 and 3.3.8.3 and between 3.3.8.1 and 3.3.8.5 must be 0.25 PPM or less.

3.3.8.7 Restore the power switch to + 12 VDC.

3.3.9 Test No. 4 Frequency-Load Stability.

3.3.9.1 Observe the frequency of the TCVCXO. After it has stabilized to within ± 0.5 HZ, record the frequency on the 1000 ohms line.

3.3.9.2 Switch the RF load to 800 ohms.

3.3.9.3 Record the frequency on the 800 ohm line.

3.3.9.4 Switch the RF load to 1200 ohms.

3.3.9.5 Record the frequency on the 1200 ohm line.

3.3.9.6 Restore the RF load switch to 1000 ohms.

3.3.9.7 To be acceptable the frequency differences between steps 3.3.9.1 and 3.3.9.3, and between 3.3.9.1 and 3.3.9.5 must be 0.25 PPM or less.

3.3.10 Test No. 5 Analog Input Impedance.

3.3.10.1 Switch the ANALOG control to the CAL position and adjust the audio oscillator to 1KHz at a level of 1.00 ± 0.01 VRMS as observed at TP1. Record the actual value on the CAL line.

3.3.10.2 Switch ANALOG to ZIN.

3.3.10.3	Observe TP1 and record the RMS value on the ZIN line.
3.3.10.4	To be acceptable the value recorded on the Zin line must be greater than half the value recorded on the CAL line.
3.3.11	Test No. 6, Analog Frequency Deviation.
3.3.11.1	Put the ANALOG switch into the 0 volts position. After allowing the TCVCXO stabilize in frequency to within ± 0.5 HZ, adjust the frequency with Fadj to center frequency within ± 0.5 HZ. Record the output frequency.
3.3.11.2	Switch ANALOG to + 0.75 VDC.
3.3.11.3	Record frequency on output to ± 0.5 HZ.
3.3.11.4	Switch ANALOG to + 0.6 VDC.
3.3.11.5	Record frequency on output to ± 0.5 HZ.
3.3.11.6	Switch ANALOG + 0.4 VDC.
3.3.11.7	Record frequency on output to ± 0.5 HZ.
3.3.11.8	Switch ANALOG to + 0.2 VDC.
3.3.11.9	Record frequency on output to ± 0.5 HZ.
3.3.11.10	Switch ANALOG to - 0.2 VDC.
3.3.11.11	Record frequency on output to ± 0.5 HZ.
3.3.11.12	Switch ANALOG to - 0.4 VDC.
3.3.11.13	Record frequency on output to ± 0.5 HZ.
3.3.11.14	Switch ANALOG to - 0.6 VDC.
3.3.11.15	Record frequency on output to ± 0.5 HZ.
3.3.11.16	Switch ANALOG to - 0.75 VDC.
3.3.11.17	Record frequency on output ± 0.5 HZ.
3.3.11.18	Put ANALOG to OV.

3.3.11.19 Verify the frequency observed on output agrees with the frequency recorded previously at OV to ± 1 HZ.

3.3.11.20 To determine if the performance data of this test is acceptable, do the following data reduction.

3.3.11.20.1 Taking the OV frequency as a reference, prepare a table of frequency deviations by subtracting the OV frequency from all readings.

3.3.11.20.2 Prepare a plot of frequency deviation vs. EANLG.

3.3.11.20.3 Determine the average slope of this plot this is the Analog Modulation Deviation Sensitivity and must be 500 HZ / volt ± 50 HZ / volt.

3.3.11.20.4 Draw a straight line, with the average slope through the plotted points in such a way that the plotted points fall equidistant from this line.

3.3.11.20.5 Deviation of the curve through the plotted points from the best straight line fit are defined as the linearity and shall not exceed ± 37.5 HZ.

3.3.12 Test No. 7 - FSK Deviation.

3.3.12.1 Verify that the TCVCXO is operating at center frequency to within ± 0.5 HZ as described in step 3.3.11.1 .

3.3.12.2 Place CONTROL to DIG.

3.3.12.3 Place FSK to +Δ.

3.3.12.4 Observe the frequency and record the value to ± 0.5 HZ.

3.3.12.5 Place FSK to -Δ.

3.3.12.6 Observe the frequency and record the value to ± 0.5 HZ.

3.3.12.7 To be acceptable the frequency differences between center frequency and the values recorded in Steps 3.3.12.4 and 3.3.12.6 must lie in the range of 300 to 325 HZ.

3.3.13 Shut down power.

3.3.14 Remove the TCVCXO module or hybrids from fixture as applicable.

3.3.15 Reject any module or hybrids not conforming to the test results specified herein.

4.0 NOTES - None.

TCVCXO FINAL FUNCTIONAL TEST SETUP

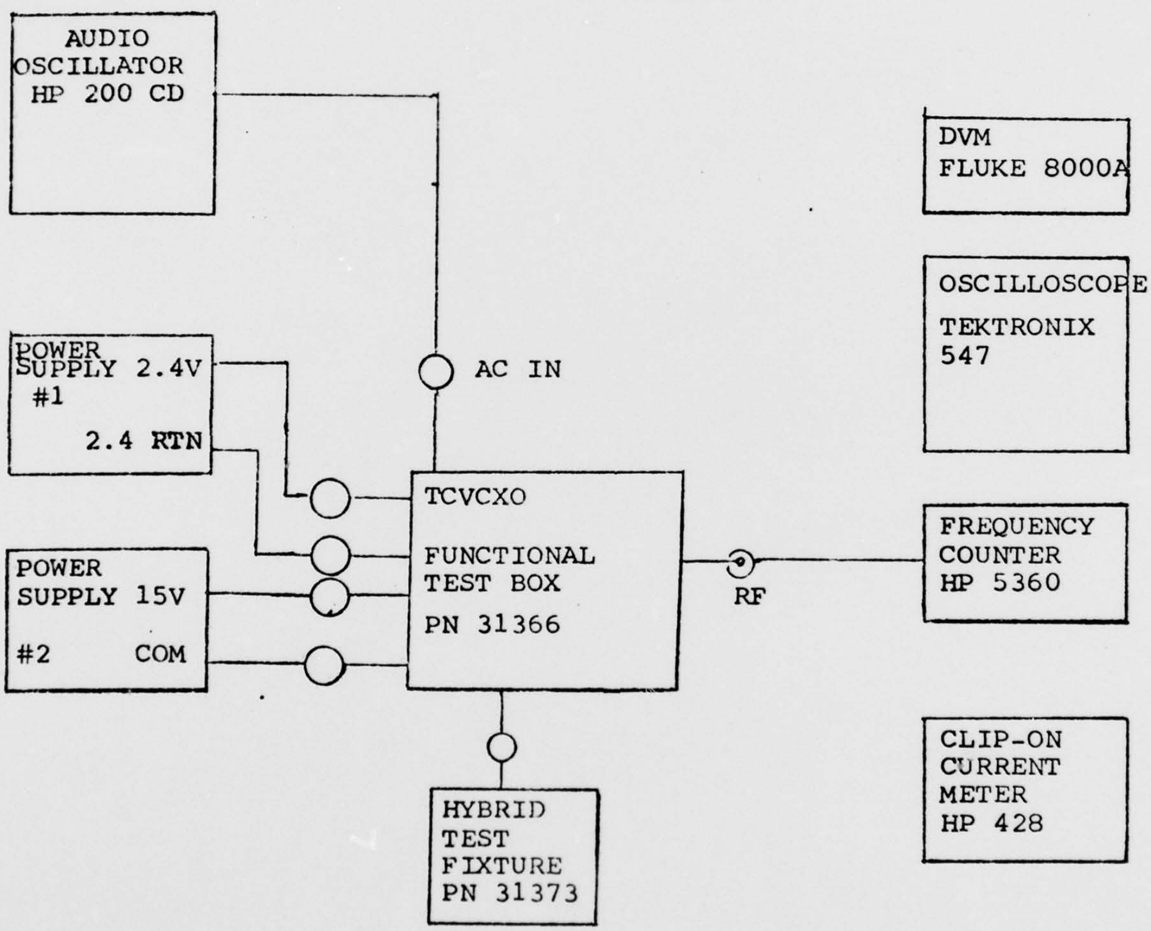


FIGURE 1

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31388 SHEET 9 OF 9	REV -

TCVCXO FUNCTIONAL TESTS

TCVCXO MODULE NO. ________
TCFG NO. ________
VCXO NO. ________ XTAL NO. ________ FREQ. ____________

DATE: ________________ BY. ________________________

TEST NO.	INPUTS SUP'Y	EANL	EDIG	ECNT	CONDITION	SPEC.	TEST POINT	ACTUAL VALUE	COMMENT
1. (Input P'r)	12	0	0	5	-	4.16 MA Max.	Cur. Lp.		
2. (RF OUT.)	12	0	0	5	R_L = 1000Ω	1.5 VPP Max	Rf Tp		
3. (FR.-V.-Stab.)	10 12 15	0	0	5	R_L = 1000Ω	0.25 PPM ______ Hz	Rf Tp		
4. (Fr.-Ld.-Stab.)	12	0	0	5	800 1000 1200	0.25 PPM ______ Hz	Rf Tp		
5. (Analog Z-in)	12	0	0	5	1.00VRMS 0.01,1 khz	200 K	TP1	Cal: Zin:	
6. (Analog Freq.-Dev. & Dev. Lin.)	12	0.75 0.6 0.4 0.2 0.0 0.2 0.4 0.6 0.75	0	5	At E_{ang} 0 v Adjust Fadj for Center Frequency After Stabilization	356.3 to 393.7 -393.7 to -356.3	Rf		
7. (Fsk. Dev.)	12	0	5 0	0	with Cntl in Anlg and Eanl OV, adjust Fadj for center freq after Stab.	300 to 325 -325 to -300	Rf		

FIGURE 2

APPENDIX J

TRS 31389
TCVCXO MODULE TRANSIENT FREQUENCY STABILITY TEST

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31389 SHEET 1 OF 5	REV –

TYPE OF SPEC

TEST REQUIREMENTS SPECIFICATION

TITLE OF SPEC

TCVCXO MODULE
TRANSIENT FREQUENCY STABILITY TEST

FUNCTION	APPROVED	DATE	FUNCTION	APPROVED	DATE
WRITER	C. Morris	3-7-77			

REVISIONS

CHK	DESCRIPTION	REV	CHK	DESCRIPTION	REV

REVISION					
SHEET NO.					

REV STATUS OF SHEETS						
	REVISION	–	–	–	–	–
	SHEET NO.	1	2	3	4	5

1.0 SCOPE

This specification applies to the testing of the temperature-compensated voltage-controlled crystal oscillator (TCVCXO) to demonstrate compliance with the Transient Freqency Stability requirement of USAECOM Technical Requirements SCS-483, dated 17 January 1975, Section 3.13, and amendment 3 thereto, dated 14 June 1976.

2.0 APPLICABLE DOCUMENTS

SCS-483	Oscillator, Crystal, Temperature-Compensated, Voltage-Controlled (TCVCXO), 17 MHz to 22 MHz, Hermetic Seal.
MIL-0-55310	Oscillators, Crystal, General Specification for
31380	TCVCXO Module
31383	TCVCXO Electrical Schematic
31382	Electrical Test Flow Plan, TCVCXO

3.0 REQUIREMENTS

3.1 TEST EQUIPMENT

Equipment Item	Description
1. Power Supply	Harrison 855B or equivalent
2. Oscilloscope	Tektronix 547
3. Frequency Counter	HP 5360
4. Keyboard Programmer	HP 5375
5. Function Generator	Exact 301 or equivalent
6. Pulse Generator	Interstate Instruments PG-2 or equivalent
7. TCVCXO Functional Test Box	31366
8. Patch cords, as required	

3.2 TEST SET-UP

The test equipment set-up will be as shown in figure 1.

3.3 TURN ON TEST

3.3.1 Test data shall be recorded on the Transient Frequency Stability form shown in figure 2.

3.3.2 Turn power off.

3.3.3 Plug the TCVCXO module into the connector on the TCVCXO Functional Test Box, and place the thermal shield in place.

3.3.4 Switch ANALOG to OV, Control to DIG, FSK to - △ , and Turn On to Norm,

3.3.5 Place the 5360 counter in the MODULE mode.

3.3.6 Turn on power.

3.3.7 Observe the frequency and verify that it is stable to within ± 0.5 Hz. Record this value as F initial.

3.3.8 Switch TURN-ON to the TEST position.

3.3.9 Set the 5375 programmer to the START position and set the 5360 counter to the EXTERNAL mode.

3.3.10 Depress the push button on the EXACT 301.

3.3.11 The 5375 programmer should be in the PAUSE mode. RECALL the contents of storage registers a, b, and c and record the frequency displayed respectively.

3.3.12 Set the 5360 counter to the MODULE mode.

3.3.13 Observe the frequency and record if as F final.

3.3.14 Turn power off.

3.3.15 To determine if the results of this test are acceptable, do the following data reduction on the test form.

3.3.15.1 Subtract F initial from each frequency recorded and enter the results in the "change in frequency" column.

3.3.15.2 The change in frequency entered in the F initial row must be less than 1 Hz.

3.3.15.3 The change in frequency entered in the F100 row must be less than 9 Hz.

4.0 NOTES

None

TCVCXO TURN-ON TEST SETUP

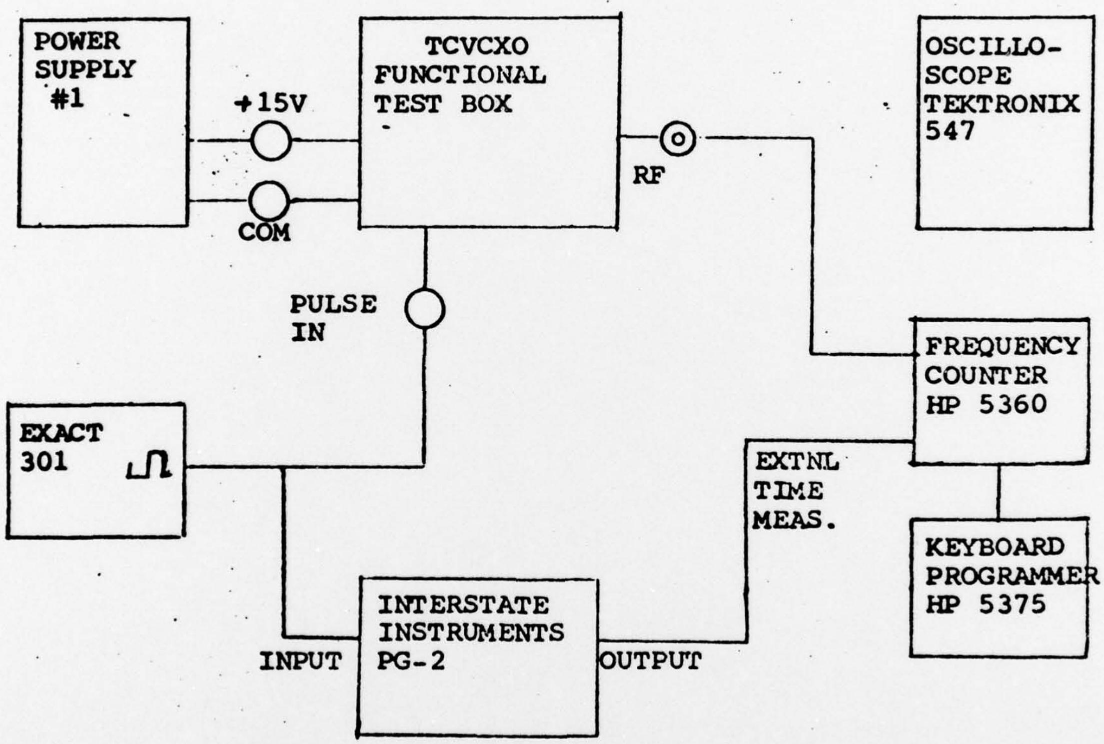


FIGURE 1

TCVCXO
TRANSIENT FREQUENCY STABILITY

TCVCXO MODULE NO: ______________

TCFG NO: ______________

VCXO NO: ______________ DATE: ______________

XTAL NO: ______________ BY: ______________

TEST NO.	FREQUENCY	CHANGE IN FREQ.
1.	$F_{initial}=$	0
2.	$F_5=$	
	$F_{50}=$	
	$F_{100}=$	
3.	$F_{final}=$	

FIGURE 2

APPENDIX K

TRS 31390

TCVCXO MODULE TEMPERATURE TEST

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31390 SHEET 1 OF 8	REV –

TYPE OF SPEC

TEST REQUIREMENTS SPECIFICATION

TITLE OF SPEC

TCVCXO MODULE TEMPERATURE TEST

FUNCTION	APPROVED	DATE	FUNCTION	APPROVED	DATE
WRITER					

REVISIONS

CHK	DESCRIPTION	REV	CHK	DESCRIPTION	REV

REVISION	–	·	–	–	–	–	–	–
SHEET NO.	1	2	3	4	5	6	7	8

REV STATUS OF SHEETS	
	REVISION
	SHEET NO.

1.0 SCOPE

This specification applies to the testing of the temperature-compensated voltage-controlled crystal oscillator (TCVCXO) to demonstrate compliance with the temperature requirement of USAECOM Technical Requirements SCS-483, dated 17 January 1975, Section 3.10 and admendment 3 thereto, dated 14 June 1976.

2.0 APPLICABLE DOCUMENTS

SCS-483 Oscillator, Crystal, Temperature-Compensated, Voltage-Controlled (TCVCXO), 17 MHz to 22 MHz, hermetic seal.

MIL-O-55310 Oscillators, Crystal, General Specification for

31380 TCVCXO Module

31383 TCVCXO Electrical Schematic

31382 Electrical Test Flow Plan, TCVCXO

3.0 REQUIREMENTS

3.1 Test Equipment

Equipment	Description
1. Power Supply	Harrison 855 B or equivalent
2. Power Supply	Harrison 855 B or equivalent
3. Power Supply	Harrison 855 B or equivalent
4. Function Generator	Exact 301 or equivalent
5. Clip On Ammeter	HP-428 or equivalent
6. Digital Voltmeter	Fluke 8000 or equivalent
7. Digital Voltmeter	Fluke 8000 or equivalent
8. Frequency Counter	HP 5248L or equivalent
9. XY Plotter	Mosely 7000 AM or equivalent
10. Oscilloscope	Tektronix 547 or equivalent
11. D/A Converter	HP 580A or equivalent
12. RCL Bridge	Cal.Std. WB 110B or equivalent
13. Oven	Delta MK 2300 or equivalent
14. Remote Oven Control (Raytheon built)	
15. Electronic Switch	31393

3.2 Test Set-Up

The test set up to be used is shown in Figure 1. Perform test with ECNTL = 5V, EDIG = 0V. To carry out this specification the TCVCXO module is to be installed in a special fixture attached to the inside cover of the Delta oven, designed to filter out the sharp thermal transients induced by normal oven cycling. The oven will be made to scan the temperature range -45°C to +75°C under program control while an XY plot is being made of center frequency and both positive and negative analog deviations. The attached TCVCXO Temperature Tests form (Figure 2) is to be filled out at the start of the test as well as during a run.

3.3 Procedure

3.3.1 Turn off power.

3.3.2 Place TCVCXO module into oven test fixture.

3.3.3 Turn power on.

3.3.4 Set EANLG to 0 VDC ECNTL to 5 VDC, and E DIG to 0 VDC.

3.3.5 Observe the frequency and allowing sufficient time for the reading to stabilize to ± 1.0 Hz, adjust the internal F ADJ for a frequency of F - 50 Hz, and record the value in the fo (Ti) blank. For this step do not insert the oven door assembly into the oven.

3.3.6 Record as TINITIAL the temperature of the TCVCXO module as read from the RCL resistor.

3.3.7 Derive the DEVIATION in hertz and enter the result on the form.

3.3.8 Set E ANLG to a positive voltage from power supply No. 1 and adjust power supply No. 1 until the frequency shifts positive from fo (Ti), step 3.3.5, by the amount of the deviation. Record the value power supply No. 1 is set to in the VD blank.

3.3.9 Switch E ANLG to OV, E CNTL to OV, Record the frequency in $F - V_D$ blank.

3.3.10 Switch E DIG to 5 VDC. Record the frequency in the $F + V_D$ blank.

3.3.11 Record the data of steps 3.3.9-10 in the appropriate columns of the DIGITAL DEVIATION form.

3.3.12 Switch E DIG to OV, ECNTL to + 5 VDC.

3.3.13 Close the oven door and lower the chamber temperature to -45°C. Allow sufficient stabilization time for the frequency to remain within ± 1 Hz.

3.3.14 Record the temperature of the TCVCXO module as read from the RCL resistor in the second row of the DIGITAL DEVIATION form (Figure 3).

3.3.15 Record the frequency in the fo column.

3.3.16 Switch E CNTL to OV and record the frequency in the $F - V_D$ blank.

3.3.17 Switch E DIG to +5V and record the frequency in the $F + V_D$ blank.

3.3.18 Switch E DIG to OV, E CNTL to +5V.

3.3.19 Start the temperature run program and engage the electronic switch into the driven mode.

3.3.20 Throughout the ensuing temperature run, it will be necessary to monitor the XY plotting to ensure that no problems develop that would reduce the value of the data being generated. Specifically the ink flow must remain controlled.

3.3.21 Commencing of -40°C and repeating every 5°C interval thereafter, the following data is to be recorded on the test form.

3.3.21.1 Observe value of the RCL and record in RCL column.

3.3.21.2 Observe TP1 and record value.

3.3.21.3 Observe 9V and record value.

3.3.21.4 Observe +12V current and record value.

3.3.21.5 Observe RF wave on scope and record peak to peak value.

3.3.22 When the temperature run reaches 75°C, RAISE THE PEN.

3.3.23 Disengage the Electronic Switch and set E ANLG to OV. Record the frequency in the fo column of the DD form.

3.3.24 Switch E ANLG to OV, E CNTL to OV. Record the frequency in $F - V_D$ blank.

3.3.25 Switch E DIG to 5 VDC. Record the frequency in the $F + V_D$ blank.

3.3.26 Record the data of steps 3.3.24-25 in the appropriate columns of the DIGITAL DEVIATION form.

3.3.27 Switch E DIG to OV, E CNTL to + 5VDC.

3.3.28 Put the oven in the manual mode and set the oven to 25°C.

3.3.29 Allow sufficient time to stablize the frequency to within ± 1°C and record the oven temperature T FINAL and the oscillator frequency fo (T_5). Shut down power.

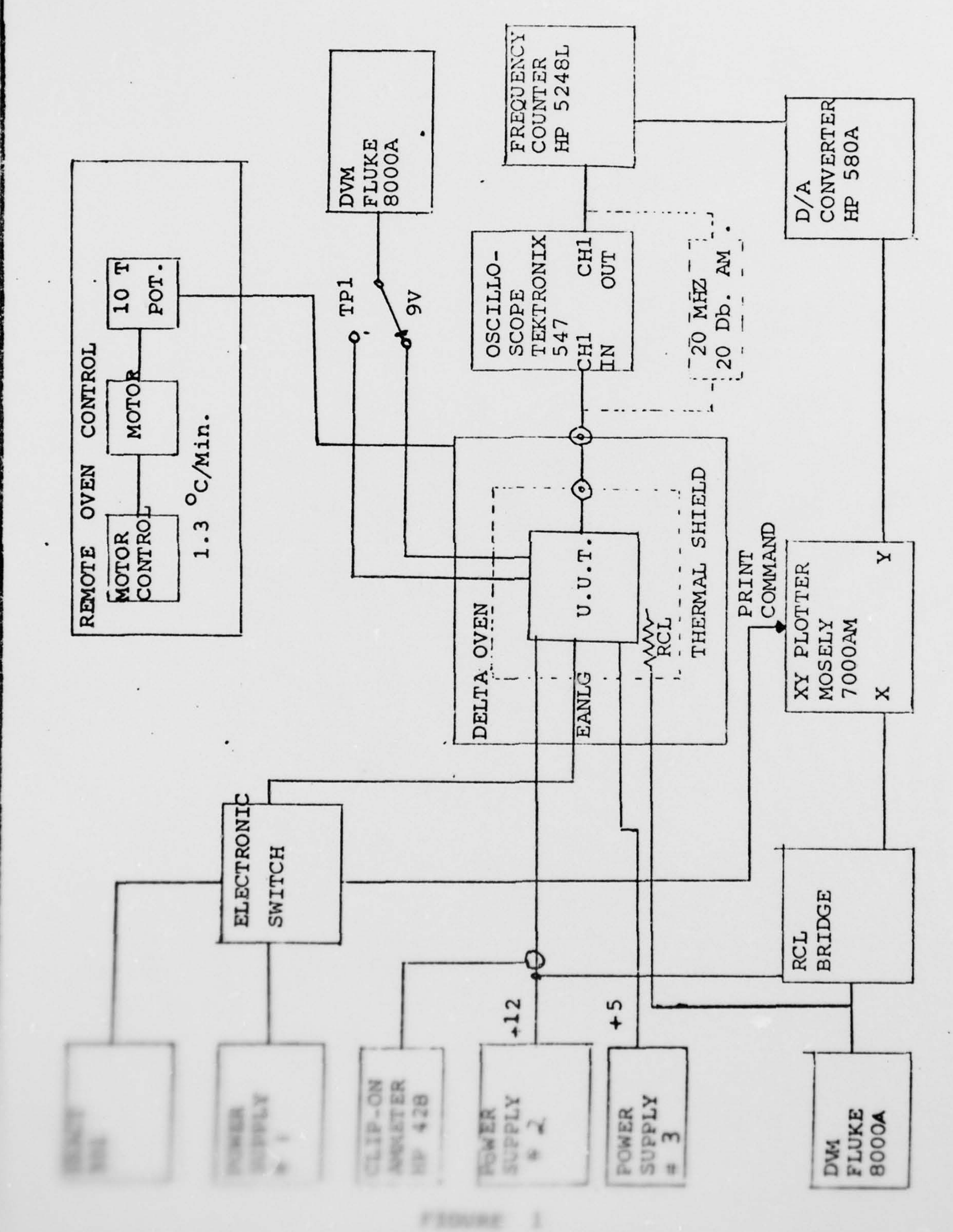
3.3.30 Remove TCVCXO module. Evaluate test data according to the following data reduction.

3.3.31 Take the XY plot and measure the difference, on the center frequency curve, between the most positive deviation and the most negative deviation and convert this value in Hz to PPM. The number so derived must be less than 5 PPM.

3.3.32 Take the XY plot and measure the difference, on the positive shift curve, between the most positive deviation and the most negative deviation, and convert this value in Hz to PPM. The number so derived must be less than 4 PPM.

3.3.33 Take the XY plot and measure the difference on the negative shift curve, between the most positive deviation and the most negative deviation and convert this value in Hz to PPM. The number so derived must be less than 4 PPM.

RAYTHEON	RAYTHEON COMPANY LEXINGTON, MASS. 02173	CODE IDENT NO. 49956	SPEC NO. 31390 SHEET 6 OF 8	REV -



TCVCXO TEMPERATURE TEST SET UP

FIGURE 1

TCVCXO TEMPERATURE TESTS

TCVCXO MODULE NO: ____________ FREQ(F) ____________ Mhz.

TCFG NO: ____________ XTAL NO. ____________

VCXO NO: ____________

$T_i = T_{initial} =$ ________ °C $f_o(T_i) =$ ____________ Hz.

$T_f = T_{final} =$ ________ °C $f_o(T_f) =$ ____________ Hz.

BY ____________ $+V_D$ ________ Volts 5F ________ Hz

± 325

DATE ____________ DEVIATION = ________ Hz.

TEMP(°C)	RCL(Ω)	9 Volt	TP1(v)	IDC(MA)	RFOUT(PP)	COMMENT
-40						
-35						
-30						
-25						
-20						
-15						
-10						
- 5						
0						
5						
10						
15						
20						
25						
30						
35						
40						
45						
50						
55						
60						
65						
70						
75						

FIGURE 2

TCVCXO TEMPERATURE TEST - DIGITAL DEVIATION

TCVCXO MODULE NO: ____________ FREQ.(F) ____________ Mhz.

TCFG NO: ____________ XTAL NO: ____________

VCXO NO: ____________

BY: ____________

DATE: ____________

TEMP(^{o}C)	RCL(Ω)	f_o(HZ)	f_+Vd (HZ)	f_-Vd (Hz)	$+\Delta$	$-\Delta$

FIGURE 3